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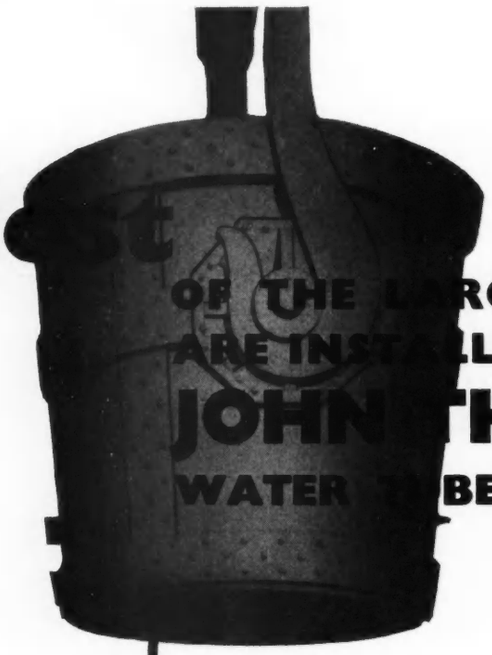

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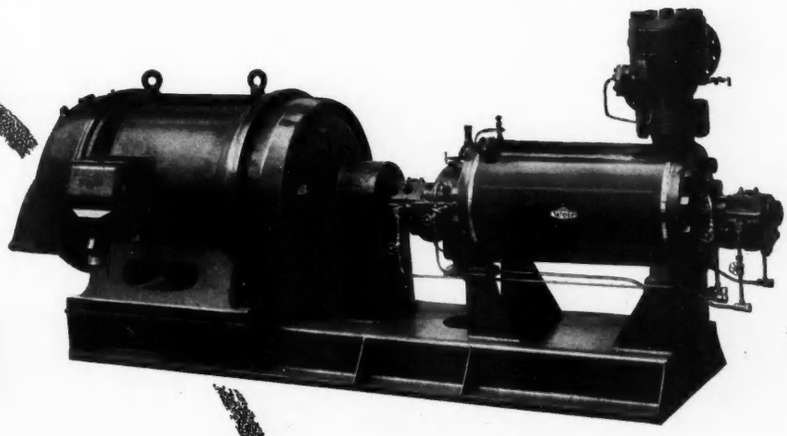

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THE TWO AXES OF TWIST IN ELASTIC PRISMS.

By D. G. ASHWELL, M.A., Ph.D.

THERE seems to be a likelihood that confusion may arise owing to the existence of two centres of twist of twisted elastic prisms without an agreed terminology for distinguishing between them; as, for example, in a recent article by Morice,* in which the term "centre of twist" is used to mean something quite different from its usually accepted meaning. The present article is an attempt to draw attention to the situation, to suggest a suitable nomenclature, and to make clear the distinction between the two centres by showing how their positions in a member may be simply derived from the two quite separate stress-systems which decide them. Of these two derivations, the first is essentially similar to that given by Lockwood Taylor† and by Hoff.‡ The second is believed to be new.

It has long been a curious paradox that the stress-distribution given by the St. Venant theory for the torsion of a twisted elastic prism is independent of the axis about which the prism is assumed to twist. The first authors in recent times to direct attention to this paradox seem to have been Duncan, Ellis and Scruton,§ who remarked in 1933 that it would thus appear as though the position of the axis were actually indeterminate—"a conclusion quite at variance with physical intuition."

They then considered the behaviour of a prismatic elastic cantilever, attached at one end to a support, and twisted at the other. They defined the centre of twist, at any cross-section of the cantilever, as that point in the cross-section which does not move relatively to the support as the cantilever is twisted. The locus of such points in different cross-sections, which was found to be a straight line, was called the "axis of twist," and is the axis about which the twisted cantilever rotates relatively to the support. By appealing to the reciprocal theorem of Betti and Maxwell, they showed that, while the position of the centre of twist in a cross-section depends, to some extent, on the nature of the support, in most practical cases it approximates very closely to the position of the shear centre of the cross-section. The shear centre, or flexural centre, is defined as the point in a cross-section at which a lateral load must be applied to the cantilever to produce lateral deflection but no rotation of the cross-section in its own plane.

The term "axis of twist," as defined by Duncan and his co-authors, was used without ambiguity until 1949, when Cullimore published a paper describing some theoretical and experimental work on "The Shortening Effect."* This term refers to the effect of the second-order longitudinal strains, considered by Buckley† in 1914 and Weber‡ in 1921, which arise because different longitudinal filaments of a twisted prism distort into helices of different radii. In the course of his experiments, Cullimore noticed that the axes of twist of asymmetrical sections, twisted sufficiently to suffer large permanent strains, were quite different from the shear centre axes. He suggested that the position of the axis of twist would be that which caused the total potential energy of the system to be a minimum. If the bar has free ends, so that warping of its cross-sections is unrestricted, and the only stress-systems are the St. Venant stresses and the longitudinal stresses already mentioned, this is equivalent to saying that the energy of the longitudinal stresses will be a minimum with respect to the position of the axis of twist—the St. Venant stresses being independent of that position. This enabled him to determine the positions of the axes of twist of thin-walled angle and channel sections, and his results agreed satisfactorily with experiments.

The present author§, while examining the nature of the St. Venant paradox, also came to the conclusion that the position of centre of twist of a member without end constraints can depend only on the stresses associated with the second-order longitudinal strains of Buckley and Weber, and obtained expressions for the position of the axis of a general section for distortions (though not elastic strains) of unrestricted magnitude. He analysed the behaviour of a twisted cantilever and concluded that, if the rotation of its tip becomes large, its displacement and distortion depend on the positions of both the shear centre axis and the axis of twist for the free end condition, in a manner that was confirmed by experiment. He also found that his general expressions could be simplified for the case of small deflections of bars of the type considered by Cullimore to give identical results.

Fig. 1.

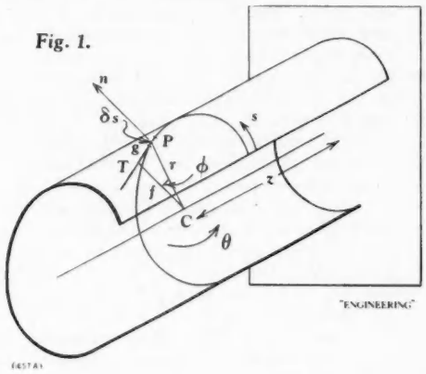


Fig. 2.

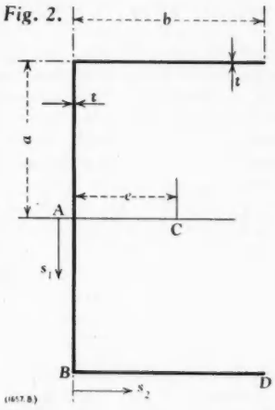


Fig. 3.

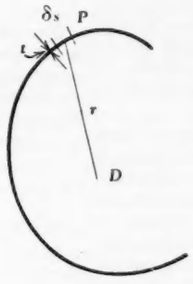
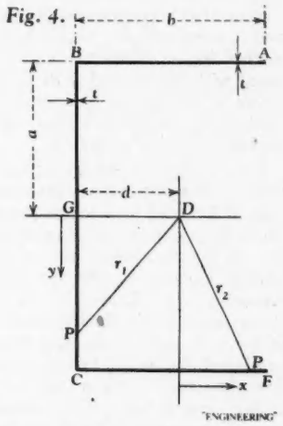


Fig. 4.



NOMENCLATURE.

It will be seen, then, that there is evidence for the existence of two quite distinct centres of twist, and the question arises of a suitable nomenclature. There is a strong case for reserving the term "axis of twist" for the axis defining the distortion of a free-ended member, and referring to the axis about which the cross-sections of a cantilever rotate as the "shear centre axis" or "flexural axis"; indeed, Timoshenko, in his account of the "Theory of Bending, Torsion and Buckling of Thin-walled Members of Open Cross-section,"* nowhere refers to the axis of twist of a cantilever, but always to its shear centre axis, even when he is using its properties as an axis of twist. However, the terms "axis of twist" and "torsional axis" have so long been in general use as referring to the axis about which the cross-sections of a cantilever rotate when it is twisted (see, for example, R. J. Roark's *Formulas for Stress and Strain*, published by the McGraw-Hill Book Company in 1938) that it would be both pedantic and confusing to suggest that their meanings be now altered.

In seeking a more acceptable way of distinguishing between the two axes, it is helpful to return to Duncan, Ellis and Scruton. These authors showed that, though the St. Venant stress-distribution is independent of the axis of twist chosen, there can, in fact, be obtained from the St. Venant theory a position of the axis for any specified relationship between the system of co-ordinate axes chosen and the root cross-section of the cantilever. This is because, in the absence of modifying stresses due to any particular method of support at the root, the root cross-section, like all other cross-sections, suffers warping out of its plane; and, to specify the relationship between the cantilever and the frame of reference defined by the co-ordinate axes, three points on this cross-section must be regarded as fixed. The choice of these points decides the direction of the plane at the root of the cantilever relative to which its displacement is measured, and this is found to decide the position of the axis of twist relative to the cantilever. In practical cases, the direction of this plane will depend on the system of local stresses which must be added to the St. Venant stresses in order to produce continuity between the cantilever root and its support. Thus, as pointed out elsewhere,† the axis of twist obtained by Duncan, Ellis and Scruton is seen to be an axis defining the nature of the displacement of the cantilever relative to its support. On the other hand, the axis of twist of a free-ended bar defines the nature of the distortion of the bar—that is, the displacements of various parts of the bar relatively to each other and independently of any particular support or frame of reference.

The author therefore tentatively suggests that it would be a reasonable and satisfactory solution to the problem of nomenclature to call the old axis the "axis of displacement" and the new one the "axis of distortion." The term "axis of twist" can then be used for either, whenever the

* "On Centres of Twist in Non-Homogeneous Beams," by P. B. Morice. *Magazine of Concrete Research*, October, 1952.

† "Theory of Torsion Bending," by J. Lockwood Taylor. *Aircraft Engineering*, October, 1938.

‡ "Stresses in Space-Covered Rings in Monocoque Fuselages," by N. J. Hoff. *Jl. of the Royal Aeronautical Soc.*, February, 1943.

§ "The Flexural Centre and the Centre of Twist of an Elastic Cylinder," by W. J. Duncan, D. L. Ellis and C. Scruton. *Phil. Mag.*, Series 7, vol. 16 (1933).

* "The Shortening Effect," by M. S. G. Cullimore. *Research: Engineering Structures Supplement* (1949).

† "The Bifilar Property of Twisted Strips," by C. Buckley. *Phil. Mag.*, Series 6, vol. 28 (1914).

‡ "Die Lehre der Drehungsfestigkeit," by C. Weber. *Forschungsarbeiten No.* 249, *V.d.I.* (1921).

§ "The Axis of Distortion of a Twisted Elastic Prism," by D. G. Ashwell. *Phil. Mag.*, Series 7, vol. 42 (1951).

* S. P. Timoshenko, *Jl. Franklin Inst.*, March, April and May, 1945.

† D. G. Ashwell, *loc. cit.*

context makes it clear which is intended. Formal definitions of the two axes thus would be: the axis of displacement of a prismatic elastic cantilever, attached to a support at one end and twisted by a torque applied to the other, which is free, is the axis about which cross-sections of the cantilever rotate in their planes relatively to the support; and the axis of distortion of a twisted elastic prismatic bar is the axis which coincides with the longitudinal filament (real or imaginery) which does not distort into a helix, but remains straight when the bar is twisted.

Methods are given below for determining the positions of the axes of displacement and the distortion of thin-walled open sections. By showing, in this way, the two quite different stress-systems that give rise to the two axes, the distinction between them may, perhaps, be made clearer.

Determination of Centre of Displacement.

Most texts on this subject derive the position of the centre of displacement—i.e., the intersection of the axis of displacement with a given cross-section—by using its identity with the shear centre. This has the disadvantage that the nature of the stress-system which decides its position is obscured, and it seems desirable to give here a simple direct method for its determination, which can be compared with the method later to be given for the centre of distortion. As previously stated, the method is essentially similar to that given by Lockwood Taylor* and Hoff.†

Fig. 1, on page 769, shows a cantilever of thin-walled open section, attached at one end to a rigid support, and twisted by a torque applied at the other. Three stress-systems will affect its behaviour, namely, the St. Venant stresses, the stresses necessary to prevent warping at the root cross-section, thus producing its continuity with the support, and the second-order longitudinal stresses of Buckley and Weber. Of these three, only the second need be considered, for the St. Venant stresses are independent of the position of the axis, and the Buckley and Weber stresses, being of the second order, can be ignored when compared with the first-order warping stresses.

Let C be the centre of displacement at the cross-section shown, z be measured from the support along the axis of displacement, s be measured along the median line of the cross-section, and n along the normal to this line at any point P. Let C T be the perpendicular from C to the tangent to the median line at P. Let C P $= r$, C T $= f$, P T $= g$, the angle T C P $= \phi$, and let the rotation of any cross-section about the axis of twist, relative to the support, be θ, as shown.

Then, if it may be assumed that the shape of the cross-sections of the member does not change when the member is twisted, and that C has the same position in all cross-sections, the generator through P of the median surface distorts into a curve which lies on a circular cylinder, the axis of which is the axis of displacement. Its deflection, measured circumferentially round this cylinder, will be $r\,\theta$, and thus its curvature in the tangent plane at P may be taken as $r\left(\frac{d^2\theta}{dz^2}\right)$, provided that $r\left(\frac{d\theta}{dz}\right)$ is small. This curvature will take place about an axis parallel to C P. It has, in addition, a curvature about an axis in the plane of the cross-section, at right-angles to C P, but this is of the second order of $\frac{d\theta}{dz}$ and will be neglected.

Consider a strip of width δs, as shown, which contains P and is bounded by two lines that were generators of the median surface when unstrained. The curvature $r\left(\frac{d^2\theta}{dz^2}\right)$ of this strip about C P may be resolved into a curvature

$$r\left(\frac{d^2\theta}{dz^2}\right)\cos\phi = f\left(\frac{d^2\theta}{dz^2}\right)$$

about P n, and

$$r\left(\frac{d^2\theta}{dz^2}\right)\sin\phi = g\left(\frac{d^2\theta}{dz^2}\right)$$

about P T. These curvatures will cause strain gradients along P n and P T, and hence stress gradients which, in the absence of lateral stresses on the strip, will be given by

$$\left.\begin{aligned}\frac{\partial p}{\partial s} &= -\mathrm{E}f\frac{d^2\theta}{dz^2}\\ \text{and}\qquad \frac{\partial p}{\partial n} &= \mathrm{E}g\frac{d^2\theta}{dz^2}\end{aligned}\right\} \quad . \quad (1)$$

where p is the longitudinal stress in the strip, and E is the Young's modulus of the material of the cantilever.

At any point, the stress gradient in the direction P n will be substantially constant over the (small) thickness of the section, and so the average stress in the strip will be that at the median line, p_c, say, given by

$$\frac{dp_c}{ds} = -\mathrm{E}f\frac{d^2\theta}{dz^2}. \quad . \quad . \quad (2)$$

Now, if the member is subjected to pure torque about the axis of displacement, the stresses p_c, when integrated over the cross-section, must have no resultant force or moment about any line in the plane of the cross-section; thus, if t is the thickness of the section at P,

$$\left.\begin{aligned}\int t\,p_c\,ds &= 0\\ \int t\,x\,p_c\,ds &= 0\\ \int t\,y\,p_c\,ds &= 0\end{aligned}\right\}, \quad . \quad . \quad (3)$$

where the integrations are performed over the whole length of the cross-section, and x and y are the co-ordinates of P in any convenient set of linear axes in the plane of the cross-section. The term f may now be expressed in terms of the assumed co-ordinates, X and Y, of C, and equation (2) may be integrated, $\frac{d^2\theta}{dz^2}$ being constant for the cross-section considered. The constant of integration and the values of X and Y may then be found from the three equations (3), and thus the position of the centre of displacement, C, may be determined.

It must be noted that the distortion of the elementary strip of width δs, due to the shearing force that will arise in its own plane, has been neglected; this is legitimate for open sections, provided that the length of the member considered is large compared with the dimensions of its cross-section. It can be proved that the results obtained by this method are identical with those obtained by the usual method of determining the shear centre.

As an example of the use of the method, consider the symmetrical channel section, the dimensions of which are shown in Fig. 2, on page 769. It is reasonable to assume that the centre of displacement, C, lies on the axis of symmetry at a distance e from the back of the channel, as shown. If s is measured from A, the intersection of the channel with the axis of symmetry, then symmetry suggests that p_c will be either an even or an odd function of s; while the fact that, from equation (2), $\frac{dp_c}{ds}$ is not zero when s is zero means that, of these two, it must be odd, and hence p_c is zero at A. The stress gradient, $\frac{dp_c}{ds}$, from A to B is, from equation (2), $-\mathrm{E}\left(\frac{d^2\theta}{dz^2}\right)e = -k\,e$, say, where k is a constant; and thus $p_c = -k\,e\,s_1$, being $-k\,a\,e$ at B. From B to D the stress gradient is $-k\,a$, and thus $p_c = -k\,a\,e - k\,a\,s_2 = -k\,a\,(e + s_2)$, where s_2 is measured from B. The use of symmetry has ensured that the resultant of the stresses p_c, and their resultant moment about any line parallel to A B, are both zero, and it remains to equate to zero their moment about some axis not parallel to A B. Thus, taking moments about A C,

$$-k\,e\,t\int_{-a}^{+a} s_1^2\,ds_1 - 2\,k\,a^2\,t\int_0^b (e + s_2)\,ds_2 = 0,$$

giving

$$e = \frac{3\,b^2}{2\,a + 6\,b}. \quad . \quad . \quad (4)$$

The negative sign means that the centre of displacement is on the other side of the web of the channel. This is the usual expression for the shear centre of the channel.

Determination of Centre of Distortion.

In determining the centre of distortion, the case of a twisted prism in which the ends are free to warp is considered. This means that no warping stresses exist, and attention must be directed to the second-order longitudinal stresses of Buckley and Weber. Fig. 3, on page 769, shows a typical cross-section of a thin-walled open member which is subjected to a torque producing a constant twist per unit length of τ. The distortion centre is at D, and a typical longitudinal strip intersects the cross-section at P. The dimension of this strip, measured along the median line of the cross-section, is δs, and its thickness is t, the thickness of the section at P; the point P is distant r from D. When the prism is twisted, longitudinal filaments distort into helices, having a common axis passing through D, but different radii. This means, as Buckley and Weber have pointed out (see also Timoshenko*), that they will suffer different longitudinal strains, and these strains will produce different tensions and compressions in them. Suppose that the strain suffered by the filament (real or imaginary) lying along the distortion axis is e_0. Then it can be shown, from the geometry of the helix that, provided the quantity $r\tau$ is small, the strain of a filament distant r from the axis is equal to $e_0 + \frac{1}{2}(r\tau)^2$, where τ is the (constant) twist per unit length of the prism. Thus, in the absence of lateral stresses on the strip at P, the longitudinal stress there will be $\mathrm{E}\left[e_0 + \frac{1}{2}(r\tau)^2\right] = p_d$, say.

Again it may be said that, if the prism is subjected to pure torque about the axis of distortion, the stresses p_d, when integrated over the cross-section, must have no resultant force or moment about any line in the plane of the cross-section; and thus,

$$\left.\begin{aligned}\int t\,p_d\,ds &= 0\\ \int t\,x\,p_d\,ds &= 0\\ \int t\,y\,p_d\,ds &= 0\end{aligned}\right\}, \quad . \quad . \quad (5)$$

where the integrations are performed over the whole length of the cross-section, and x and y are the co-ordinates of P in any convenient set of linear axes in the plane of the cross-section. The term r may now be expressed in terms of the assumed co-ordinates X and Y of D, and e_0, X, and Y may be determined from the three equations (5).

It must be emphasised that this analysis is not applicable to all types of cross-section. Unfortunately, the nature of the approximations involved is difficult to make clear without repeating the more rigorous analysis given elsewhere.† However, it may be used with confidence for sections in which angle of twist per unit length is small, and which are very much stiffer in bending than in twisting.

* † *Loc. cit.*

* *Strength of Materials, Part II*, by S. P. Timoshenko, 2nd ed. D. van Nostrand Co., New York, U.S.A. (1940).

† D. G. Ashwell, *loc. cit.*

Results obtained from it agree with those obtained by Cullimore's energy method, and by the approximate expression given by the present author in the reference already cited.

As an example of the method, the distortion centre of the channel already considered will be found. In Fig. 4, on page 768, D is the distortion centre, assumed to be on the axis of symmetry at a distance d from the back of the channel. The longitudinal stress at some point P, at a distance r from D, will be

$$p_d = \mathrm{E}\,[e_0 + \tfrac{1}{2}\,(r\tau)^2] \quad . \quad (6)$$

and if x and y are measured as shown, the first equation of (5), above, becomes

$$2\,t\,(a+b)\,\mathrm{E}\,e_0 + \mathrm{E}\,t\,\tau^2 \int_{-a}^{+a} r_1^2\,dy + 2\,\mathrm{E}\,t\,\tau^2 \int_{-d}^{b-d} r_2^2\,dx = 0, \quad . \quad (7)$$

where

$$r_1^2 = y^2 + d^2 \quad . \quad . \quad (8)$$

and

$$r_2^2 = x^2 + a^2. \quad . \quad . \quad (9)$$

The equations (7), (8) and (9) provide an equation for e_0, which becomes

$$2e_0\,(a+b) = \tau^2\,a\,(\tfrac{1}{3}\,a^2 + d^2) + \tau^2\,b\,(a^2 + \tfrac{1}{3}\,b^2 - b\,d + d^2). \quad (10)$$

The use of symmetry has ensured that the moment of the stresses p_d about G D is zero; it remains to equate to zero the moment about some axis not parallel to G D. Thus, taking moments about B C,

$$2\,\mathrm{E}\int_{-d}^{b-d} [e_0 + \tfrac{1}{2}\,(r_2\tau)^2]\,(x+d)\,dx = 0, \quad (11)$$

where e_0 is given by equation (10) and r_2 by equation (9). This is an equation for d, defining the position of D, and reduces to

$$d = \frac{4\,a^3 + 3\,a\,b^2 + b^3}{8\,a\,b + 2\,b^2}.$$

If $b \to 0$, $d \to \infty$, an absurd result which arises because the section is then no longer very much stiffer in bending than in twisting, and the condition stated above for the analysis to be accurate is no longer satisfied. This result is identical with that given by Cullimore,* and with the author's approximate expression, mentioned above. The method can easily be extended to deal with non-homogeneous sections of the type considered by Morice.*

STEEL AND PIG IRON PRODUCTION.—The British Iron and Steel Federation state that steel production in November reached the record level of 363,000 tons per week and pig iron a record level of 228,500 tons per week. Both these figures, and the total production of both commodities for the first 11 months of the year, show an increase of about 10 per cent. on the corresponding figures for 1952.

AWARD OF THE BAYLISS PRIZE.—It has been announced by Mr. D. Winston Aldred, F.R.I.B.A., head of the Department of Architecture and Building, South-West Essex Technical College, Walthamstow, that, for the second time in two years, a full-time student of the department has been awarded the Bayliss Prize of the Institution of Civil Engineers. This year's recipient is Mr. W. J. Chodzko-Zajko.

ENGINEERING APPRENTICES AT FRASER AND CHALMERS.—The Fraser and Chalmers Engineering Works of the General Electric Co., Ltd., at Erith, have published a well-illustrated booklet entitled "Opportunity for Youth—Engineering Apprenticeships at Fraser and Chalmers." It describes the products of the works since their establishment in 1891, including notes on the romantic careers of the founders. Details of the various apprenticeship schemes available are then given, and of the work which those who take them up will have to perform. There are informative accounts of the equipment of the shops, and the scope for those who join the firm is emphasised by calling attention to the social activities which are available. Further information may be obtained from the Education and Training Officer at the works.

* *Loc. cit.*

LITERATURE.

Thermodynamics Applied to Heat Engines.

By E. H. LEWITT, Ph.D., B.Sc., A.M.I.Mech.E. Fifth edition. Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, London, W.C.2. [Price 30*s.* net.]

SINCE this book first appeared in 1933 its size has increased in successive editions from 347 pages to 820; the price has advanced in even greater ratio. The present edition differs mainly from its predecessor by containing additional matter on gas turbines and jet propulsion, including supersonic ram-jets. A new chapter of considerable length, entitled "Further Applications of Thermodynamics," covers a wide range of information, mostly supplementary to that previously given, among its subjects being the humidity of air, the vibration energy of molecules, the metastable expansion of vapours, the liquefaction of gases, and the heat pump. One of the new features, however, demands special notice. This is a section in which the author, according to the words of his preface, "has developed a conception of entropy from the availability of heat for conversion into work."

His conception is that "The total entropy of a given substance at a given temperature, and reckoned above zero temperature, is the total work done by a gradual cooling process through a series of Carnot engines, each causing unit temperature drop and each being supplied with equal amounts of heat, the process being continued down to zero temperature." Dr. Lewitt attempts to demonstrate this proposition by means of a temperature-entropy diagram showing a succession of Carnot cycles, but what his method ultimately proves, though he fails to realise it, is that the entropy of a substance with a given specific heat is a function of its temperature alone. This, of course, can be immediately seen by integrating the equation $d\,\phi = \frac{d\,\mathrm{H}}{\mathrm{T}}$, which has been the standard definition of entropy since the days of Clausius. His extraordinary notion that entropy is synonymous with work done arises from his arbitrary choice of 1 deg. temperature drop for his Carnot cycles. For the latter to conform to the continuous cooling curve, they would, of course, all have to be of infinitesimal dimensions, so that, in the limit, all their area would have vanished and their summation would simply produce a line of length equal to the total entropy. By allowing them all a 1-deg. temperature drop, he makes their areas numerically equal to their widths, whence he concludes that the area of a rectangle can be the same kind of thing as the length of one of its sides; thus the work represented by the collection of Carnot rectangles will be identical with the entropy change corresponding to their aggregate length.

Furthermore, by regarding the available heat of a substance, when cooled to zero temperature, as limited to the amount that could be turned into work by a series of Carnot engines, each rejecting to waste the heat it did not use, he overlooks the fact that, with Carnot engines and absolute zero at his disposal, it would be very easy so to arrange things that the whole of the heat in the substance would be available for work. From this misunderstanding, coupled with his curious ideas about the identity of entropy with available heat, he concludes that equal amounts of work per pound could be theoretically derived from two gases, regardless of their respective temperatures and pressures, provided only that their entropies were the same, and he gives a temperature-entropy diagram in support of this contention. Put into figures, it means that as much work is theoretically obtainable from steam at 50 lb. pressure and 300 deg. F. as from steam at 700 lb. pressure and 940 deg. F., because the entropy is the same in both cases. Finally, on page 762, the reader is told that the efficiency of Carnot engines, working with equal temperatures and ranges, will vary with the temperature-entropy curve of the substance from which they extract their heat. It is deplorable that such misinformation should disfigure a work of such pretentions, and, in our opinion, students would be well advised to disregard the section.

Electro-Magnetic Machines.

By R. LANGLOIS-BERTHELOT, M.I.E.E., M.A.I.E.E. Translated and revised in collaboration with Lieut.-COLONEL H. M. CLARKE, T.D., M.Sc., M.I.E.E. MacDonald and Co. (Publishers), Ltd., 16, Maddox-street, London, W.1. [Price 65*s.* net.]

THE French are frequently credited with more logical minds than the British. This may partly be due to the precision of their language which, although spoken only by some 75 million people as compared with 200 million who speak English, is still the accepted language of international diplomacy. All Frenchmen are not able to use their precise language with precision, but when they are, they may reach a clarity of expression not common in English. This was illustrated in the French edition of this book, first published some ten years ago, though its value equally depended on the analytical mind of its author, who was able so clearly to present the fundamentals of his subject.

This admirable translation has preserved the virtues of the original. Mr. C. W. Marshall, who was largely responsible for the translation being undertaken, remarks in a foreword that "the book is unique . . . in excluding as far as is practicable everything that is transitory and in retaining what appears to be permanent." It is stated in the general introduction that the book "is a sort of grammar or abstract study of the machines" and, later on, that "the reader coming into contact for the first time with the subject may experience some difficulty in assimilating the grammar developed"; nevertheless it is thought that "abstraction has not been carried too far." These remarks need not alarm potential purchasers. A treatise which deals with the basic principles of electrical machines in a systematic way cannot be other than valuable in clarifying the ideas of students and even of designers.

It is pointed out at the outset of the volume that electrical machines may be grouped in four main families—static transformers, polyphase synchronous machines, polyphase induction machines, and direct-current machines. Various practical and theoretical aspects of each family are reviewed, such as its importance to industry, method of use, basic principles, etc., with an historical summary. Much of this material may appear elementary and even obvious, but the broad sketch leads up to the detailed consideration of the relation between the form and materials of construction and electromagnetic theory, which is dealt with in the longest section of the book, and lies at the basis of design.

The theoretical considerations on which design must be based having been established from first principles, sections are then devoted to electrical machines from the points of view of the designer and the user. The first of these deals with the properties of the materials of construction, in their mechanical and electrical aspects; the second deals with operating considerations, on the principle that the user should understand the fundamental properties of the machines in his charge. Many practical considerations are dealt with in this section and such matters as mechanical protection and methods of cooling are touched on. A further section of the book deals with the abnormal conditions of operation, which may have important influence on design, but which could not be discussed in earlier sections without interrupting the discussion of the fundamentals of machine design.

THE IRON AND STEEL INSTITUTE.

(*Concluded from page* 744.)

Water Cooling of Open-Hearth Furnaces.

The last paper considered on Tuesday afternoon dealt with "The Water Cooling of Open-Hearth Furnaces." It was by Mr. A. M. Frankau, of the Plant Engineering Division of the British Iron and Steel Research Association, who stated that a series of measurements had been made, on a number of open-hearth furnaces, of the flow rate and temperature rise of the cooling water supplied to the individual cooling units. The heat losses imposed by these units were an important factor in furnace operations, as it had been shown from these trials that they could involve a high proportion of the heat input. It was calculated that the required heat input for a given heat loss was in the ratio of 1·8 : 1 for oil firing and 2·1 : 1 for producer-gas firing. Trials on a tilting furnace during a single campaign had shown that the measured heat loss rose from 11·4 per cent. to 15·7 per cent. of the total heat input. This increase was due to the severe erosion of the refractory covering the cooling units in the port ends. It should not be thought, however, that water cooling was an unnecessary evil in an open-hearth furnace. Water-cooling could and did play an important part in increasing the life of vulnerable parts of the furnace, and possibly allowed harder driving. But these losses could not be ignored, and every effort should be made to reduce them where possible. The largest heat losses occurred in units such as furnace chills and door frames, where there were surfaces unprotected by refractory and subject to direct radiation or gas impingement. It was therefore recommended that an endeavour should be made to ensure the covering of the cooling units wherever possible.

Mr. Y. A. Calderwood, who opened the discussion, said that there was a complete lack of uniformity or standardisation in the matter of the water-cooling of open-hearth furnaces. There were occasions when the local source of water supply was such as virtually to dictate how the water cooling should be effected, in a way not always to the liking of furnace builders. In future papers of this nature the quality and source of supply of the cooling water should be stated, as well as the means employed in circulation.

His firm, the Wellman Smith Owen Engineering Corporation Limited, had been asked by B.I.S.R.A. to give their views on what they considered the proper application of water cooling—not a simple matter by any means. In the first place, the number of cooling units which should be used on an open-hearth furnace was very much a matter of opinion, and could depend upon local considerations. Perhaps the true answer to this request was to ask how seriously the steel industry was going to tackle the problem. Their general experience was that on an open-hearth plant the water inlet valve was turned full on right from the start, and there it stayed. To tackle the problem properly would cost money; for example, measuring instruments and possibly automatic control would be required, or special hand-control valves.

Dr. A. H. Leckie stated that heat losses by water-cooling were accepted apparently with equanimity by various steelmakers and this showed that the seriousness of the problem could not have been properly realised. The magnitude of some of the losses was really staggering. One of the largest sources of loss of heat were the door frames. He had always heard it said that the chief reason for water-cooling a door frame was that charge drivers would knock down the brickwork of an ordinary brick door without this type of protection. If so, he wondered whether Mr. Frankau had gone into the question of the relative merits of small and large doors, because presumably the door should be as large as possible in order to get a lot of material in quickly with the minimum damage to the frames. On the other hand, this would mean a greater heat loss both through air infiltration and through water-cooling. He wondered whether Mr. Frankau considered all these aspects with a view to minimising water-cooling losses as well as just measuring what they were.

Mr. C. R. Banks felt that the paper did not go quite as far as might have been hoped, in that it studied only the losses which resulted from water-cooling. Mr. Frankau had stated some of the advantages to be derived from the use of water-cooled fitments, but from the figures he quoted he was not very convincing. His suggestion that a particular furnace was losing the equivalent of 1,400 gallons of fuel oil a day implied that there might be an easy way of improving fuel practice. Of course, that implication was erroneous. The 1,400 gallons a day loss could not be got back by eliminating water-cooling. If water-cooling were dispensed with there would soon be losses in front wall repairs and other heat losses. Why was water-cooling used so extensively in steel plants throughout this country and the rest of the world? To summarise, it maintained a furnace in good shape for a longer period of time, it helped to maintain tightness around the doors, and it assisted materially in eliminating hot repairs. All these factors, added together, made for an efficiency which did not unduly diminish during the campaign of a furnace, and that was a most desirable condition.

Mr. M. P. Newby said that the emphasis that afternoon had rightly been mainly on the heat loss in water-cooling systems, but there was another aspect of the problem, and that was the quantity of water used in the system. The heat loss would depend mainly on the overall furnace design, but the quantity of water used would depend mainly on the internal design of the water-cooling system. If there were a dead zone of no circulation in a system, that was exceedingly inefficient, and must be eliminated. The next speaker, Mr. J. H. Flux, thought that the author should go much farther and attempt to establish in a rather more realistic manner the losses which occurred in uncooled furnaces at those parts which were now sometimes water-cooled. The last speaker, Mr. A. L. Cude, said that some of the heat losses in an open-hearth furnace were unavoidable; they took place in any case, and just happened to be intercepted by the water-cooling. It would, however, be well worth while to pay attention to the exposed water-cooled surfaces on the inside of a furnace to see to what extent unnecessary surfaces could be reduced.

Mr. A. M. Frankau, in a brief reply, said that he was not against water-cooling as such. He never intended his paper to be a denunciation of water-cooling. What he had tried to show was that if water-cooling were installed, the cooling units must be adequately protected from radiation in order to reduce the losses. He had a great deal more information than he had been able to put into the paper, and he regretted that he had left out the data on the water quality and source of supply. He now had the figures and would remedy the omission.

When the members reassembled at the London headquarters on the morning of Wednesday, November 25, for the second day of the meeting, the President, Mr. James Mitchell, C.B.E., occupied the chair.

Brittle Fracture in Iron Alloys.

The first four papers considered all dealt with brittleness and fracture in iron alloys of various types and were jointly discussed. The first paper on "The Notched Slow-Bend Test as a Brittle-Fracture Test" was by Professor J. E. de Graaf and Dr. J. H. van der Veen of the Royal Dutch Blast Furnaces and Steelworks, Ijmuiden, Holland. The authors stated that the test under consideration was a notched slow-bend test used by them in their investigations of brittle fracture. The investigation had shown that the tendency to start and propagate fibrous cracks and the tendency to the crystalline mode of crack propagation were both involved. According to the authors' experience, these two tendencies were not related to each other in a simple manner. The research results had stressed the desirability of choosing a test in which the various criteria could be determined separately, and would seem to justify the procedure employed in the notched slow-bend test.

The second paper, on "The Fracture of Alpha Iron" was by Dr. Constance F. Tipper and Dr. E. O. Hall. It described work carried out mainly in the Engineering Department of the University of Cambridge. The authors stated that the main object of their investigation was to determine the amount of plastic deformation involved in the fracture of crystals when such fracture was of the cleavage type, distinguishing between the deformation that preceded fracture and that involved in actual partition. It had been intended to use large pure-iron crystals for this purpose but only a few were successfully prepared. Some large-grained silicon-iron was available and this silicon ferrite proved more satisfactory for the investigation. Carbonyl iron had also been used. The formation of Neumann lamellæ and cleavage planes had been studied and the stress to fracture measured. It had been observed that slip bands and Neumann lamellæ were not found in the same ferrite grain, again supporting the view that they did not readily form in material already plastically deformed. All the fractures investigated had been accompanied by lamellæ formation, but in no instance was fracture initiated in or near bands, even when they were present at an early stage in the test.

The third paper dealt with "Intergranular Brittleness in Iron-Oxygen Alloys" and was by Mr. W. P. Rees and Mr. B. E. Hopkins of the National Physical Laboratory, Teddington, Middlesex. The authors stated that they had investigated the tensile and impact properties of high-purity iron and iron-oxygen alloys at various temperatures covering the tough to brittle transition. The addition of more than 0·003 per cent. of oxygen produced marked intergranular embrittlement, accompanied by a sharp rise in impact transition temperature. Oxygen had little effect on the resistance to plastic deformation, but it had considerable effect in reducing the brittle fracture strength. The addition of manganese largely counteracted the influence of oxygen.

The fourth paper on "The Cleavage Strength of Polycrystals" was by Dr. N. J. Petch, of the University of Leeds. The author stated that the present work indicated that the cleavage strength of polycrystals was controlled by the theoretical cleavage strength on the grain-boundary region, which opened up the possibility of subtle composition effects in this special region, by the grain size which determined the stress-concentration factor, and by a constant. The plastic strain at fracture was greater when the grains were finer and the strain-hardening rate was lower.

Mr. A. J. K. Honeyman, in opening the discussion, stated that when the problem of brittle fracture had first received attention, there had been an urgent demand for the production of better steels, and it was then quickly found that manganese was the practical answer to the problem; but it was not known why manganese was so effective. Moreover, it was not known exactly what was being tested when an impact test was carried out and that was the subject dealt with by Professor de Graaf and Dr. van der Veen in their paper. He would like to have some information about the test: for example, how long did it take to carry out, and how was the temperature of the notch-bend maintained constant during the slow-bend test? Two of the remaining papers dealt with the more fundamental aspects of the problem of brittle fracture. With regard to the paper by Mr. Rees and Mr. Hopkins, perhaps the two most interesting and puzzling points were, first, the fact that they had not been able to find any intergranular phase to account for the progressive increase in the intercrystalline failure and in weakness; and secondly, the fact that all the other specimens were coarse grained. Unfortunately, every author seemed to have his own method of describing grain size, and this gave their readers difficulties.

Dr. N. P. Allen said that ten years ago it was being argued whether the notch-bar value had any relation at all to the tendency of a mild steel to undergo brittle fracture in certain circumstances. Now, the argument was on what was the best way of determining the transition temperature, and whether one method was giving that transition temperature more accurately than another within a scatter of 10 deg. or 20 deg. Dr. Petch wished to persuade metallurgists that the dominant factor in brittle fracture was the grain size; but it should be pointed out that his specimens contained not enough carbon

to saturate the ferrite, and consequently precipitations of carbon might be going on throughout all the experiments. It was necessary to know the effect of carbon going into and out of solution.

Mr. J. E. McLennan said that work similar to that described by Dr. Tipper and Dr. Hall had been proceeding at the National Physical Laboratory during the past two years. Over 50 crystals had been tested in tension at temperatures ranging from 100 deg. C. to —253 deg. C. The iron contained 0·003 per cent. of carbon with similar amounts of other impurities. In many ways their results confirmed those reported in the paper. They had studied the effect of two variables, temperature and orientation, on the behaviour of single crystals in simple tension. At the higher temperatures crystals of any orientation deformed by slip to give 100 per cent. reduction in area. At low temperatures crystals of certain orientations cleaved without prior deformation, others twinned, and still others, of different orientation, deformed by slip. At still lower temperatures, all crystals became brittle. The next speaker, Dr. A. Wells, said that Professor de Graaf and Dr. van der Veen, in their paper, had given metallurgists another test; but the competition was rather strong in these tests, and their test would have to be a good one if it were to survive. It had strong chances, however, because the authors had shown that the test had an advantage over, say, the Charpy test in that it gave a much more definite transition point.

Mr. G. Murray Boyd stated that the problem of notch brittleness in mild steel, or rather the problem of its control from the practical engineer's point of view, had given rise to the invention of many different types of tests, all intended to discriminate between suitable and unsuitable steels from this viewpoint. The multiplicity of such tests had set a serious problem for those in whose interest it was to select the one which was the best. This selection was in itself a problem comparable in magnitude and difficulty with that of elucidating the phenomenon itself. From the user's point of view, any such test must stand or fall on its ability to comply with three main conditions, namely: (1) it must correlate with service performance; (2) its indications must be as free as possible from personal errors of judgment; and (3) it must be practical and economical to apply. From their paper, it was evident that conditions (2) and (3) were fairly well met by the test proposed by Professor de Graaf and Dr. van der Veen, but little evidence was given on condition (1). The reascn for this was, of course, that such correlation was exceedingly difficult to establish, and had not in fact been definitely established for any known test for this property, not even for the Charpy V-notch test. In view of the inherent difficulty of direct correlation with service performance, the investigator could fall back on the indirect method of seeking criteria which agreed between themselves, irrespective of the geometry of the test specimens. This was found to be the case for fracture appearance criteria, in agreement with the present paper, and was a strong argument in favour of the proposed test. Equal claims, however, could be be made for several other tests.

Mr. T. S. Robertson said that Dr. Petch had presented new information on the cleavage and yield strengths of steel and iron at low temperature and this new information, together with the simple relationships with grain size, should lead to an eventual understanding of the mechanism of initiation of fracture. Some recent work on the effect of grain size on the propagation of running cracks, however, revealed the gap which had yet to be covered before this work could be applied to the catastrophic failure of structures.

Professor J. E. de Graaf, in his reply to Mr. Honeyman's questions in the discussion, said that their notched slow-bend test was principally adiabatic and not isothermal. The temperature rise by contact with the surroundings had been found to be only half a deg. C. per minute, and the test was carried out in half a minute. There was thus no temperature rise as a result of heating by the surroundings. Another question was whether the temperature would rise owing to the deformation of the test-piece. To avoid that, the test-piece would have to be surrounded by a cooling medium and the test would have to be done very slowly in order to enable the heat generated during the propagation of the fibrous crack to be dissipated in the body of the test-piece.

At this stage of the proceedings the President said that, in view of the time, the other authors would reply in writing.

Properties of High-Purity Iron Alloys.

The last paper taken was entitled "Tensile and Impact Properties of High-Purity Iron-Carbon and Iron-Carbon-Manganese Alloys of Low-Carbon Content." It was by Dr. N. P. Allen, Mr. W. P. Rees, Mr. B. E. Hopkins and Mr. H. R. Tipler, of the National Physical Laboratory. The authors stated that they had measured the tensile and impact properties of their alloys at various temperatures spanning the tough-to-brittle transition for various heat treatments above and below the A_1 point. It had been found that the rate of cooling from the austenitic region had a large effect on the properties obtained. A fast rate of cooling that favoured retention of the carbon in solution (but also decreased the grain size) generally gave improved proof stress and tensile strength, a higher cleavage strength at — 196 deg. C., and a lower temperature of transition from tough to brittle fracture in the Charpy impact test. On water quenching a good combination of tensile and impact properties was obtained at a carbon level of about 0·05 per cent., but still further improvement was obtained by adding manganese. Water-quenching iron-carbon alloys containing up to about 0·006 per cent. of carbon resulted in intergranular brittleness and a deterioration in properties. A slower rate of cooling that produced carbide films at grain boundaries and around areas of pearlite gave high impact transition temperatures. Some evidence had been forthcoming which suggested that the quench-ageing of iron-carbon alloys, which involved a rise in impact transition temperature, was at least retarded by manganese.

Dr. A. Wells, in opening the discussion, said that it was time that the cleavage strength of materials could be measured at temperatures other than that of liquid air. One possible way in which it might be done would be with spherical samples in which all trace of shear at the centre could be eliminated, and the stresses might be induced by some such treatment as a sudden immersion in a different-temperature bath.

A subsequent speaker, Mr. A. J. K. Honeyman, asked whether it was possible to obtain variable-carbon steels with a fine grain. Mr. W. Barr stated that, in referring to 0·05 per cent. carbon steels, Dr. Allen had said that he hoped that the steel industry would take note of and develop steels along those lines. The steel industry was aware of the effects of carbon and manganese in particular. That morning, Mr. Honeyman had mentioned the question of the manganese effect. He believed that, in the paper that Mr. Honeyman and he had given in 1946, they had been the first to point out the profound influence of manganese, and the steel industry had taken full cognisance of that. One of the most important factors in the work of Dr. Allen and his collaborators was the effect of cooling rates. Therein lay the greatest possibility of improving the notch-ductility of mild steels economically.

Dr. N. P. Allen, in his reply, said that Dr. Wells had spoken about the need for means of measuring the cleavage strength at temperatures above that of, say, liquid air. That was certainly a very important problem. The lines upon which they were thinking were rather in terms of determining the precise stress distribution behind a notch and thereby being able to measure eventually the cleavage strength at temperatures of the order of that which obtained in transitions from tough to brittle fracture in the notch-impact test. Mr. Honeyman had asked whether it was possible to obtain fine grain in low-carbon materials. He should be able to answer that question better than the authors of the paper if he were referring to fine grain in commercial steels. There was a distinct difficulty in maintaining a fine-grain size in high-purity materials.

ELECTRONIC ARC SUPPRESSION IN TRACTION RECTIFIERS.

On page 100, *ante*, we published an article by Mr. S. R. Judd on a system of arc suppression in mercury rectifiers, the object of which is to ease the duty on the main alternating-current circuit-breaker in the event of a short-circuit or overload on the rectifier or of an "arc-back" or "back-fire" in its cylinder. This system has now been applied by the General Electric Company, Limited, Kingsway, London, W.C.2, to a 1,500-kW rectifier which has been installed in the Sefton substation of the New South Wales Government Railways.

This substation has been built to meet the increasing demands on the 1,500-volt electric railways in the neighbourhood of Sydney, which have been caused by rapid housing development, and will enable the existing maximum load of about 58,000 kW, some 18,000 kW of which is supplied by rectifiers, to be met. The new equipment, which is designed to operate in parallel with the other plant in the substation, comprises a rectifier transformer, the primary winding of which is supplied at 33 kV through an outdoor oil circuit-breaker with a rupturing capacity of 500 MVA. The transformer, which is also of the outdoor type, is fitted with an off-circuit tapping switch on the primary side, thus enabling voltages of 32·35, 31·5, 30·65 and 30 kV to be selected, and is wound delta/double six-phase, double star, the star points of the appropriate secondary windings being linked by separate interphase transformers which are mounted in the main tank. A 230-volt tertiary winding is provided for energising the rectifier auxiliaries.

The rectifier is of the twin-cylinder pumpless steel-tank type, each cylinder being fitted with six side-arm main anodes and control grids as well as three auxiliary anodes. Cooling is effected by an electrically-driven fan mounted below the cylinder the speed of which is controlled by a saturable reactor. Surge diverters of the carborundum-disc multi-gap type are provided in each anode circuit. The output voltage of the rectifier ranges from 1,458 volts at double full load to 1,579 volts at half load, the power factors under these conditions being, respectively, 0·93 and 0·96. The no-load loss for the complete equipment is less than 11 kW. After continuous operation at full load in an ambient temperature of 40 deg. C., the rectifier will withstand overloads of 50 per cent. for 20 min., 100 per cent. for 3 min., 200 per cent. for 1 min. and 300 per cent. for 5 sec.

As already mentioned, the rectifier is fitted with electronic arc-suppression apparatus. On the occurrence of a fault this causes a strong negative bias to be applied to all the control grids, thus preventing any further output from the rectifier. This apparatus is actuated by three current transformers in the alternating-current circuit to the rectifier transformer. The secondary windings of these transformers are connected in open delta and, though no voltage of system frequency is present across their open ends, one of triple frequency appears owing to the saturation of the cores. This triple-frequency voltage is applied to the control grids of a pair of thyratrons through a single-phase isolating transformer. When either the positive or negative peak of the signal voltage exceeds the negative bias of the associated thyratron triggering occurs and causes negative bias to be applied to the grids of the main rectifier. Arc suppression therefore occurs immediately the current in any phase of the alternating-current supply exceeds a predetermined value.

If repeated faults occur in the external circuit, the arc-suppression apparatus will operate three times and the rectifier will then be automatically locked out for a predetermined time. In the event of a failure of the negative bias supply to the control grids the main oil circuit-breaker is tripped. The suppression apparatus is capable of responding to a rapidly rising fault current within 0·001 sec., but to prevent switching transients from causing spurious operation, the circuit is arranged so that the response is delayed for about 0·002 sec. from the occurrence of the fault.

AUTOMATIC WINDER AT LYNEMOUTH COLLIERY.

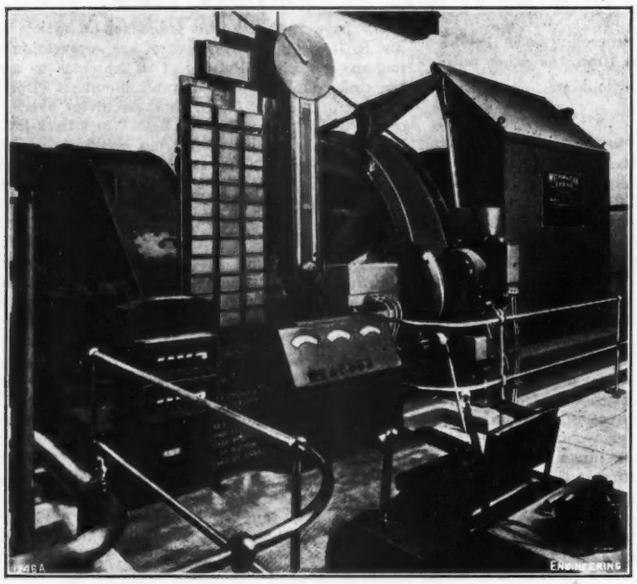


FIG. 1. 1,225-H.P. AUTOMATIC ALTERNATING-CURRENT WINDER.

FIG. 2. BANK CONTROL POSITION.

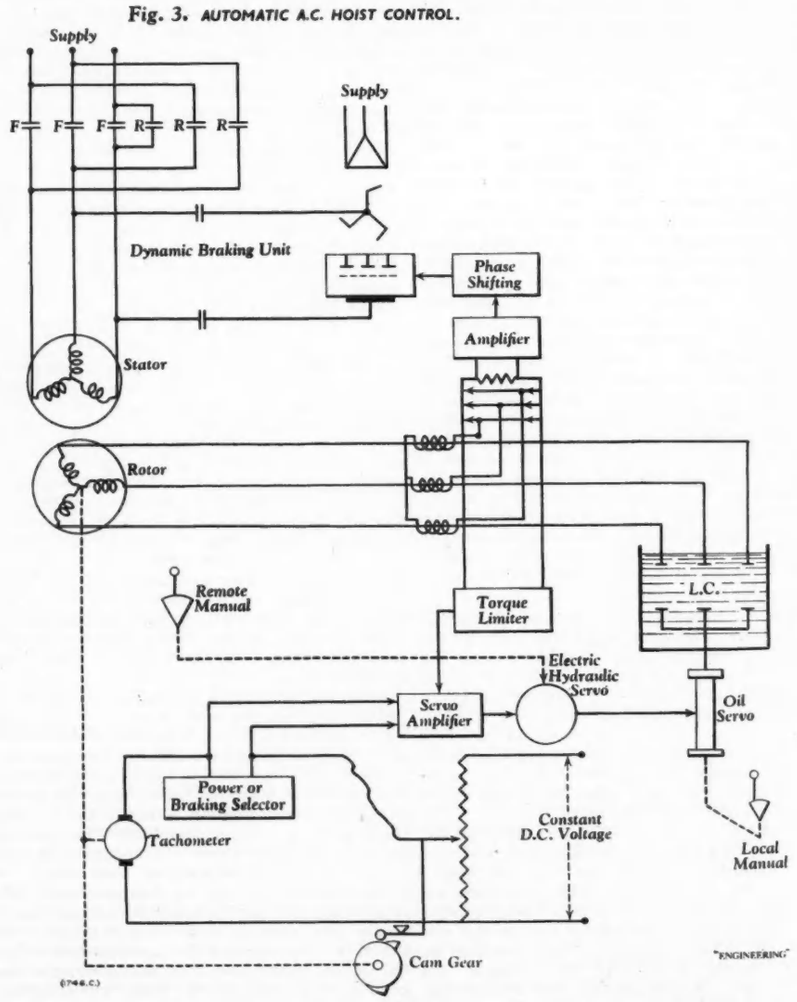
AUTOMATIC ALTERNATING-CURRENT WINDER AT LYNEMOUTH COLLIERY.

FOR some time the economic advantages of using alternating current instead of the Ward Leonard system on automatic electrically-driven winders has been recognised. Although the National Coal Board is now recommending that all new machines should be capable of being made automatic, until recently the only winder of this kind was one installed in 1935 by the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, in the Lynemouth No. 1 shaft of the Ashington Coal Company, Limited, Newcastle-on-Tyne. It is therefore interesting to record that this year the same company has successfully commissioned a 1,225-h.p. 6·6-kV automatic alternating current winder in the No. 2 shaft of the same colliery. This winder, a view of which is given in Fig. 1, is equipped both for automatic and manual control, either from the engine house or from the bank, and is provided with the company's transductor-controlled dynamic braking system. A diagram of this system, which is supplied with direct current from a grid-controlled mercury rectifier, is given in Fig. 3.

The local manual control, which is provided for use when carrying out maintenance work, but not for normal winding, is operated by electrical control and mechanical brake levers. The former directly actuates a servo motor on the liquid controller and the latter the brake control valve. Single slot gear is employed, so that the driver has only to move the electrical control lever into the forward or reverse positions. He also has a direct view of the drums and depth indicator—all typical features of a normal winder.

The remote manual control, which is provided for both "men" and service winding, is also effected electrically, as well as by mechanical brake levers, which are installed at the bank position. This position is illustrated in Fig. 2, which shows the winder equipment and car-tippling control. In this case the electrical control lever is coupled to the slider of a potentiometer, which is supplied with a direct-current voltage from a stabilised source. The voltage selected by the driver is fed into the moving coil of an electro-hydraulic servo motor, thus causing its output ram to take up an appropriate position. This ram is coupled mechanically to the main oil servo-motor control valve, which operates the liquid controller, so that for every movement of it there is a corresponding movement of the oil servo motor. Hence for every position of the remote electrical control lever there is a corresponding position of the liquid controller.

Fig. 3. AUTOMATIC A.C. HOIST CONTROL.



AUTOMATIC COLLIERY WINDER.

Fig. 4. RAISING AND LOWERING FULL LOAD.

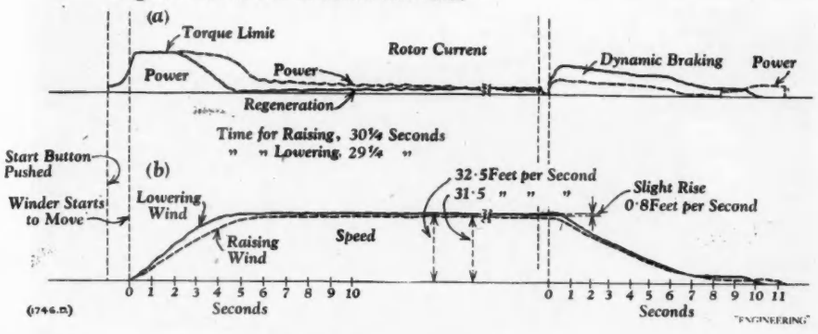
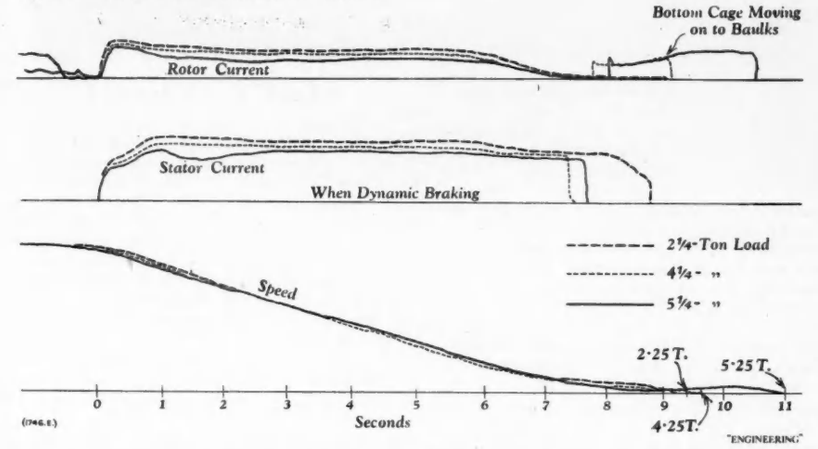


Fig. 5. RAISING-DUTY RETARDATION CURVES.



The driver at the bank can thus control the torque of the winder. Similarly, the brake lever is coupled through gearing to a Selsyn which, in turn, is connected to a receiver Selsyn in the winder house. This receiver Selsyn controls the position of the valve on the brake engine, so that for every movement of the remote brake lever there is a corresponding movement of the mechanical brake.

The primary function of the Lynemouth winder is to raise coal in 5-ton tubs and this operation is carried out automatically when the banksman presses push buttons. This official, in addition to starting the winder, also operates the car-tipping equipment. Automatic winding is carried out on the closed-loop system, in which the required speed signal is derived from a potentiometer, actuated by unidirectional cam-gear, and is electrically compared with the actual speed signal, which is derived from a tachogenerator driven by the winder. The "error" signal, which results from the difference in these two speeds, is then amplified and fed to the electro-hydraulic servo motor which, in turn, operates the liquid controller. The torque applied to the winder depends on the magnitude of the speed error and the selection of power or braking torque is determined by its polarity. A torque-limiting circuit prevents the winder from being subjected to more than twice the full-load torque.

Extensive tests have been carried out with various raising and lowering loads, during all of which the winder operated automatically, including the final landing. A comparison of the winder speed and motor current for extreme conditions of raising and lowering a full load of 5 tons is given in Fig. 4. In order to simplify the arrangements, the winder is allowed to accelerate freely under the influence of the available torque when on automatic operation, whether raising or lowering. It is therefore governed only by the peak torque permitted by the control system. This method allows the winder motor to develop its peak torque during acceleration and thus reduces the time of winding when a load less than the maximum is being raised or any load is being lowered. As shown in Fig. 4, the resulting accelerations are not excessive. When raising loads the motor is run at below synchronous speed as on a normal winder, but for lowering it was considered more economical to run it above synchronism, that is, regenerating. Accordingly, the control system is arranged so that when a load is being lowered the motor operates regeneratively during the full-speed period. Whether raising or lowering, the winder is retarded by dynamic braking and the lower curve in Fig. 4 shows that the rise in speed when changing from regenerative to dynamic braking is less than 3 per cent.

Since this winder is primarily intended for automatic raising duty, a more detailed comparison of the effect of raising various loads on the retardation period will be of interest. Fig. 5 shows the rotor current, stator current and winding speed, from which it will be seen that the speed-time curve is consistent for all loads, thus indicating the high accuracy obtainable with this speed-control system. A series of tests was also conducted at an artificial bank without using tubs, the full braking effort being applied to stop the cage once the minimum creep speed had been reached. It was found that the stopping accuracy was within ± 1½ in. for all raising loads.

The National Coal Board has ordered a 1,225-h.p. winder similar to that just described for the Lynemouth No. 1 shaft (where it will replace the original winder), as well as three 450-h.p. winders, two for Luton and one for Ellington Colliery.

THE ASSOCIATION OF VERMICULITE EXFOLIATORS.—We have received a copy of a small brochure, published by the Association of Vermiculite Exfoliators, Plantation House, London, E.C.3, setting out the properties of exfoliated vermiculite and its applications as a heat insulator. Its specific heat is 0·2 and its thermal conductivity 0·45 B.Th.U. per square foot per hour per inch per deg. F.; its density varies between 4½ lb. and 10 lb. per cubic foot, according to grading. The brochure lists the member firms of the association and copies may be obtained from the secretary at the above address, price 6*d.* each.

SOUND AND TELEVISION BROADCASTS OF THE CORONATION.

A PAPER on "Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" was presented by Mr. W. S. Procter, Mr. M. J. L. Pulling and Mr. F. Williams at a meeting of the Institution of Electrical Engineers on Thursday, December 3, the lecture theatre being connected by radiotelephone with Montreal, where a similar gathering of the Engineering Institute of Canada was taking place.

The operations described in the paper were the largest ever carried out in Great Britain. There were five television cameras in Westminster Abbey, all but one of which were completely concealed. In addition, there were 2(cameras at various points along the processional route, in which Image Orthicon tubes were used. The sensitiveness of these tubes mitigated to some extent the effect of the poor light on a very rainy day. There were also 28 microphones in the Abbey, most of which were concealed. The outputs of these were taken to a central control room from which the mixed output was fed to a number of services, including those of newsreel film companies, and to loudspeakers along the processional route, as well as to a low-intensity loudspeaker system in the Abbey itself. This control room was the central mixing point for the sound service to the home audience and into it were brought the outputs from the microphones of the Home Service commentators at points on the route. A control room for the various overseas services was installed just outside the Abbey. Although the sound and television broadcasts were largely planned and carried out as separate operations, the television service relied entirely on the sound service for the sound pick-up within the Abbey, and sound commentators at many points relied on television screens in front of them.

Outside the Abbey, a total of 16 television cameras were set up at the Victoria Memorial, on the roof and in the forecourt of Buckingham Palace, on Victoria Embankment and in Hyde Park. The principal sound commentary points were at the Colonial Office, Trafalgar Square, the Victoria Memorial and Stanhope Gate, Hyde Park. The outputs for both sound and vision from the control points at the Abbey and on the route were taken to a television control room at Broadcasting House, the output from which was fed to the television transmitters in Great Britain, to various television recording rooms and to the Continent. The television broadcast was also recorded on seven sets of equipment in and around London, and the films were carried across the Atlantic by Royal Air Force and Royal Canadian Air Force planes. As a result, viewers in Canada and the United States were able to see records of the start of the day's events by 4.15 p.m. local time. Simultaneous broadcasts were also made by television transmitters in France, Holland and Western Germany, in spite of the fact that there were no permanent television links with these countries and the picture standards were different. All the links to the Continent were by radio.

Sound recording was another feature of the arrangements. All the British Broadcasting Corporation's recording equipment was mobilised for this purpose and there were times when 58 recording circuits were in use simultaneously. All the commentators used a lip microphone which enables the speaker to be clearly heard even in the presence of considerable noise.

The discussion was opened by the Dean of Westminster (Dr. A. C. Don), who said that perhaps the authors had not laid sufficient stress on the immense amount of preparation involved. None of the apparatus in the Abbey obtruded itself on those taking part in the ceremony and there was no evidence that the knowledge that it was being broadcast had any adverse psychological effect upon those taking part. The special lighting had brought out the features of the Abbey and enhanced the colours, while the fact that the British Broadcasting Corporation had been able to record the whole of the final rehearsal both in sound and vision and to reproduce this for some of the principal participants, had enabled some minor changes

to be made which had contributed to the smooth running of the ceremony itself.

Speaking from Montreal, Mr. J. E. Hayes, chief engineer of the Canadian Broadcasting Corporation, outlined the arrangements which had been made in Canada and had enabled the films to be shown promptly. In reply, Mr. F. Williams agreed that valuable lessons had been learnt from the recording of the final rehearsal. For example, the reproduction of the orchestra and choir was excellent if judged as a studio performance, but did not give the true acoustic impression of the Abbey, nor did it match the distant shots of the television cameras. On the day more reverberation was therefore added.

THEORY AND OPERATION OF ELECTROSTATIC PRECIPITATORS.

The 206-MW power station at Congella, Durban, is situated at sea level in a warm and humid sub-tropical climate, and is unique among large power stations in South Africa in that the boilers are fired by pulverised fuel. The dust nuisance thus caused led to electrostatic precipitators of three different makes being installed, all of which at first failed to fulfil the minimum requirements. This necessitated a great deal of research and experiment, an account of which is given in a paper on "A New Approach to the Theory and Operation of Electrostatic Precipitators for Use on Pulverised Fuel Boilers," which was presented by Mr. N. Troost to a meeting of the Supply Section of the Institution of Electrical Engineers on Wednesday, November 25. As a result of these investigations, the efficiency was improved on all units.

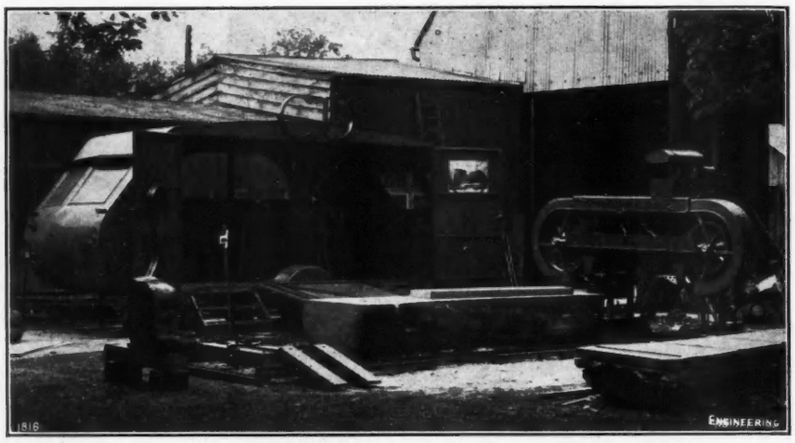
Dealing with the theory of electrostatic precipitation, the author discusses the principal factors determining the velocity with which the dust particle moves under the influence of the electric field in a direction at right angles to the gas stream. This has been termed the "drift velocity" and is one of the important criteria of precipitator performance. It has proved difficult to determine its value for various dust-gas mixtures, but a simple approximate relation for the field strength in a parallel-plate horizontal-flow precipitator has been developed, based on that generally accepted for a wire-in-cylinder precipitator unit. Expressions for calculating the theoretical performance of precipitators under conditions of non-uniform gas flow and with dust of mixed composition are also given in the paper, and it is shown that individual drift velocities for different particles can be experimentally determined. Evidence is produced to support the suggestion that pulverised-fuel dust is composed largely of two types of particles, one wholly of ash and the other of coal minus volatiles. The effective drift velocities obtained in plants operating on Natal duff and other coals are calculated for a given field strength, separate values for average ash and coke particles being given and the former being shown to have higher useful drift speeds than the latter. In fact, as predicted in theory and proved in practice, it is shown that the drift velocities of particles of the sizes encountered in actual use increase with the particle diameter, given a constant composition.

As a result of these considerations, changes were made in the precipitators at Congella which were giving unsatisfactory performance. For instance, the vertical-flow precipitators, which were fitted to three of the 200,000-lb. boilers and had a nominal full-load gas capacity of 90 cub. ft. per minute, only showed an efficiency of 70 per cent., compared with the 93 per cent. guaranteed, when the plant and rectifiers were in a satisfactory state and the operating conditions were as good as could then be obtained. These precipitators were designed for a gas velocity of 4·9 ft. per second and their minimum drift velocity was calculated to be 0·27 ft. per second. When they were first installed, tests showed that the combustible percentages in the inlet, outlet and "caught" ducts did not differ appreciably and that the gradings were also roughly the same. With a properly adjusted vertical-flow precipitator, however, the outlet dust should always contain appreciably more carbon than the inlet, so that the gas distribution was immediately suspect. Tests also showed that the gas velocity in about a third of the tubes was about 7·4 ft. per second and in the remainder about 3·7 ft. per second, so that, with the same drift velocity of 0·27 ft. per second, the efficiency should have been about 88 per cent. Steps were therefore taken to modify the outlet ducting and thereby to improve the gas distribution. When this had been done the efficiency met the guaranteed figure. The difference between the original efficiency of 70 per cent. and the calculated value of 88 per cent. was due to the gas velocity in one section being sufficiently high to cause turbulence and therefore to disturb and re-entrain some of the already deposited dust, thus lowering the effective drift velocity.

The horizontal-flow units on two of the 80,000-lb. low-pressure boilers, which had a nominal full-load gas capacity of 50 cub. ft. per minute, had a number of unavoidable bends in the inlet ducting which caused the gases to assume a whirling motion and concentrated them near the periphery of the precipitators. This motion brought about a great loss both of efficiency and electrical stability, the latter taking the form of persistent flashovers between the electrodes as soon as attempts were made to raise the voltage and current to anywhere near the normal operating values. It is known that instability of this nature bears a relation to the humidity of the gases and to the conductivity of the dusts. In these particular precipitators, the gas temperature was from 370 deg. to 400 deg. F., and this, with the normally fairly dry site conditions, would make the relative humidity of the flue gases very low. Addition of moisture could therefore be expected to cure the trouble, but this expedient, although it proved efficacious, did not quite bring the precipitators up to the desired efficiency. Moreover, it was undesirable to make arrangements for permanent gas conditioning. Fortunately, it was found that correcting the uneven gas distribution also resulted in the elimination of electrical instability. It would appear that this instability is due to an increase of ionisation in those parts of the precipitator where there are dead pockets of gas and that equalisation of flow, by eliminating these dead spaces, also removes the tendency to flashover. Correction of the uneven gas distribution further brought the precipitators to a very high degree of operating efficiency.

As indicated by these two examples, uneven gas distribution is the most common failing of precipitators and is also the most difficult, tedious and expensive to correct. One of the easiest ways of indicating this unequal distribution on a vertical-flow precipitator is to compare outlet and inlet combustible contents, as the former should be appreciably higher than the latter. Discrimination with particle size can also be used, although care must be taken to ensure that the presence of two different substances, coke and ash, in addition to the different size of particles of each substance present, does not vitiate the interpretation.

MOBILE SAWMILL.



MOBILE SAWMILL.

As a general rule, trees, other than those of small diameter used for cordwood or pit props, are cut down and the trunks hauled to some central sawmill to be sawn into planks, scantlings, and so on. At such central mills, the plant is heavy, the usual equipment including circular, band and gang saws, and the logs are put to the saw with the aid of some form of runway or trolley. An alternative procedure—that of taking the sawmill into the forest—is made possible by the development in France of the machine, "La Forestière," shown in the accompanying illustration. By sawing the timber in the forest, it can be handled cheaply or, if necessary, stacked to await convenient transport, more quickly than if the trunks have to be carted to the mill.

The machine weighs approximately 800 kg. (16 cwt.) and is about 3 m. 50 cm. (11 ft. 3 in.) long by 1 m. wide, and, to transport it into the forest, it is slid on rails into the light trailer van shown in the illustration. The van is equipped as a travelling workshop where saw-sharpening can be undertaken. For use overseas, the machine can be dismantled to be carried by native porters.

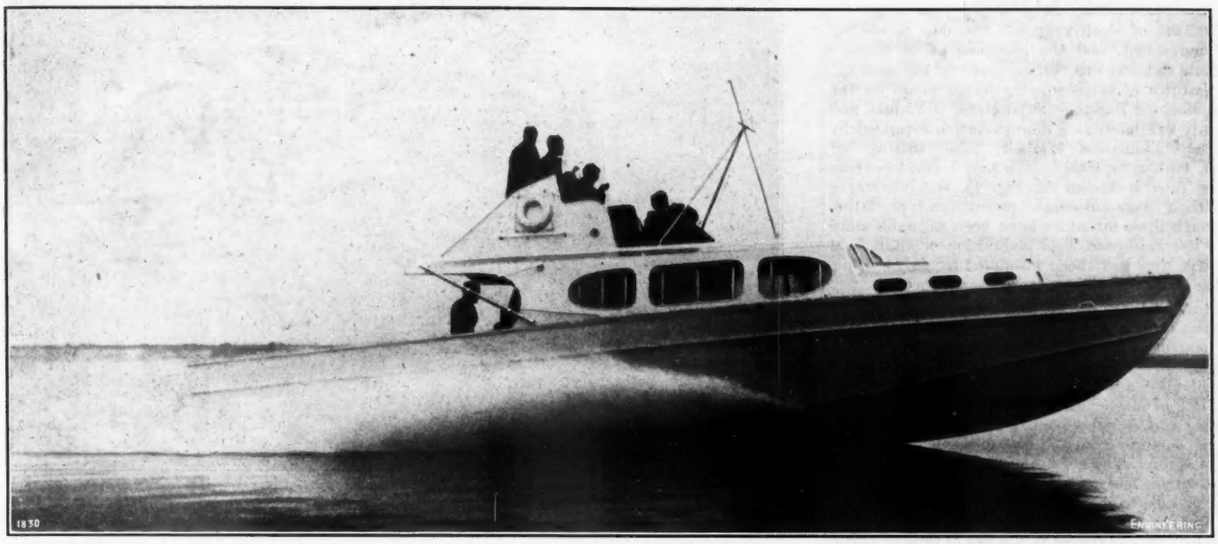
Instead of the log being hauled or pushed into the saw, the framework or chassis of the saw straddles the stationary trunk and the machine travels the length of the trunk on rails, using a heavy-duty bandsaw to cut off horizontal slices. Various forms of dogs are used to hold the logs in position. The saw is driven by a petrol or Diesel engine of 20 to 25 h.p. or by an electric motor. The bandsaw is supported throughout its length by roller bearings and the tension in the band is adjusted by an oil-hydraulic mechanism to suit the width of bandsaw being used. A single lever controls the forward, reverse and stop of the machine chassis, and an automatic feed arrangement can be added if required. The cutting gear is raised by means of an electric motor supplied from either the battery of the petrol engine or from local electricity mains; it is lowered under its own weight.

The operator, who is seated on the moving chassis, is able to "feel" how the saw is cutting, and he adjusts the speed of travel accordingly. For hardwood, and using a saw with 35-mm. teeth, the speed of the band is 22 m. per second (72 ft. per second) which can be increased to 45 m. per second with saw teeth of 50 to 60-mm. spacing. The output of hardwood varies between 1 and 2 cub. m. per hour (35 to 70 cub. ft.) according to the quality of the wood, and the saw can cope with logs up to 1 m. 35 cm. (4 ft. 6 in.) in diameter. The rails on which the chassis runs can be of any length, no foundations being required other than packing and spiking the rails. It takes about two hours to unload the saw from the van, to put it on the rails and set it to work.

The leading features of the machine are covered by patents. In order to achieve portability, the machine is much lighter than the conventional

ALUMINIUM FISHING CRUISER.

ALBATROSS MARINE, LTD., ST. OLAVES, SUFFOLK.



horizontal bandsaw doing equivalent work and it is, therefore, relatively much cheaper in first cost, principally because of the absence of heavy foundations required for a static machine. The mobile sawmill, made by Etablissement C.D., Puteau (Seine), France, has been exported in considerable numbers to the French colonies and other tropical countries, where experience has shown that it can be operated by unskilled labour.

AIR-TURBINE ACCESSORY DRIVES FOR AIRCRAFT.

A RANGE of air-turbine accessory-drive units for aircraft is under development by Rotol, Limited, Cheltenham-road, Gloucester. The air turbine is based on the design of the Air Research Division of the Garrett Corporation, Los Angeles, California, with whom Rotol, Limited, have recently concluded a licence agreement. The first installation to be produced is an accessory gearbox operating a 15-kVA alternator, a 3-kW generator and a fan for cooling the electrical accessories and the lubricating oil. The air-turbine drive has the advantage of providing constant-speed running of the alternator and generator, thus simplifying the aircraft electrical system, and, since the air turbine is not mechanically coupled to the engine, the turbine unit can be more easily installed in the aircraft. In some cases, this may reduce considerably the weight of the installation.

The air turbine is supplied with compressed air from a tapping off the main engine compressor. It is pneumatically controlled to run at constant speed by a "speed-sensing" mechanism connected to a servo actuator, which adjusts the airflow to the turbine by moving variable-area nozzles, thus enabling a high turbine efficiency to be maintained irrespective of the condition of the air supply from the engine. An overspeed cut-out is provided to come into action in the event of failure of the governing mechanism. The governing system provides a high degree of stability.

The various drives are pressure-lubricated by a pump in the gearbox sump. The lubrication system includes an oil cooler, integral with the sump. The usual filling, overflow and drain plugs are fitted. The gearbox is fitted with a centrifugal breather to prevent rise of pressure and the system is designed to allow for negative acceleration. For starting and stopping the turbine, an electrically-operated air valve is fitted in the turbine inlet, which serves also as an automatic pressure-regulating valve to limit the air-supply pressure to the turbine when the aircraft is flying at low altitudes.

ALUMINIUM FISHING CRUISER FOR THE BAHAMAS.

THE vessel shown in the accompanying illustration, known as the Gay Jane, has been designed for big-game fishing in the Bahamas and is believed to be the first all-aluminium craft to be used for this sport. It attained an average speed of 22 knots during four trial runs. The designer of the vessel was Mr. A. M. G. Peace, a director of Albatross Marine, Limited, St. Olaves, near Great Yarmouth, who were responsible for the construction. It has been purchased by Mr. Louis R. Wasey, of New York, and will be delivered early next year. The main features of this kind of craft are a high open-type wheelhouse, an observation seat in front of it, and a large cockpit in the centre of which is a pivot mounting for the "fighting-chair" used by the fisherman. Outriggers are fitted on each side of the cabin to support the fishing rod and keep the line clear of the wake, and a live-bait tank is provided beneath the floor at the rear of the cockpit; the tank is covered by a hinged hatch. The fisherman sits in the fighting-chair with his rod resting in one of the outriggers until a bite has been obtained, the rod then being pulled away from the outriggers and manœuvred by the fisherman, who gives instructions to the helmsman seated above him.

The hull is of the hard-chine type with a planing bottom, the bottom surface being flanged at the chine to form a spray deflector. The length overall is 42 ft., the beam 12 ft. 6 in., the draught 3 ft., and the displacement 14,000 lb. The craft has been constructed entirely of aluminium at the request of the owner, and riveting has been employed throughout. The aluminium was supplied by the British Aluminium Company, Limited, Norfolk House, St. James's-square, London, S.W.1, and was mostly to their N.S.5 specification, quarter hard. The bottom plating is $\frac{1}{4}$ in. in thickness and the sides $\frac{1}{16}$ in. thick. Extrusions were used for the gunwale, chine, keel and rubbing-rail and for strengthening and finishing on the bulkheads and interior fittings; some of these extruded sections were produced specially for the craft and, where necessary, were made in 45-ft. lengths. The bow is formed by a light-alloy casting weighing 56 lb. and was supplied by Non-Corrosive Metal Products, Yiewsley, Middlesex. Directly aft of the bow is the chain and anchor locker, separated from the crew's quarters by a watertight bulkhead. The anchor is of stainless steel.

The cabin, which is directly aft of the crew's quarters, has a floor space of 9 ft. by 10 ft. No lining is provided over the inner surface of the hull. The furnishings include a settee at the forward end, which can be converted into a bunk, two armchairs, a wardrobe, and a set of drawers at the aft end. The floor is covered with carpet and there are two windows on each side and three in the forward bulkhead, all fitted with aluminium Venetian blinds. Aft of the cabin is the galley which is equipped with an Electrolux refrigerator, a stainless-steel sink and a cooking compartment, into which an alcohol-heated cooker is to be fitted.

Directly aft of the bulkhead separating the galley from the cockpit are the engine compartments. Two Perkins S6M Diesel engines, developing 75/100 h.p., are installed. The engines are seated on Metalastik flexible-rubber mountings, and the propeller shafts, which are 6 ft. long and $1\frac{1}{4}$ in. in diameter, are coupled directly to the reduction gears and are supported externally by Cutless bearings. The shaft seals are of the floating type and the two propellers are each 25 in. in diameter. The engines are covered by hinged hatches, lined with 2 in. of glass-wool acoustic insulation, and form bench seats.

The flying bridge, as can be seen in the illustration, is built on top of the awning. Smith's engine instruments and Teleflex controls are fitted. A car-type steering wheel is used and it is connected to the two rudders by stainless-steel cables, running on aircraft-type sealed ball-bearing pulleys. The rudders, which are fabricated from light alloy, each have independent connections to the steering wheel, and a Vernier adjustment is provided.

The floor of the cockpit, which is self-draining, is covered with linoleum. Inspection hatches are provided for access to the propeller shafts and two fuel tanks are fitted between the engines, directly beneath the floor. The tank filler-caps are placed under a hinged tread-plate at the entrance to the galley and fresh-water tanks are fitted under the galley floor. A 12-volt lighting system is provided by two Oldham batteries of 120 ampere-hour capacity, installed in one of the engine compartments and two 24-volt batteries of 140 ampere-hour capacity are located in the other compartment for engine starting. About 28 watertight compartments are provided in the bottom of the hull. The finish of the craft is cream and silver.

GAS-TURBINES FOR L.C.C. SEWAGE POWER-HOUSE.—London County Council are proposing to use gas-turbines as the prime-movers in their power-house at the Northern Outfall Works. The turbines will drive both air-blowers and generating sets and, for fuel, will use methane from the sludge digestion plant. The power-house is part of the 3,000,000*l.* diffused air plant in the extension scheme for the Works.

COPYING LATHES WITH ELECTROMAGNETIC TOOL CONTROL.

THE use of electromagnetic clutches to control tool movement, and the provision of an entirely separate slideway in a vertical plane for the tailstock, are features of three copying lathes made by the Heid Machine Building Corporation, of Vienna, and recently exhibited at a demonstration arranged by Newman Industries, Limited, Yate, Bristol. Of these, two were Heid "Sensitast" multi-purpose lathes (one is shown in Fig. 1) and the other was their semi-automatic production-type lathe. Although these machines have been available since the First European Tool Exhibition of 1951, held in Paris, they have been improved recently. Some details of their design are therefore given here.

Although they can be used for ordinary turning between centres, these lathes are primarily supplied for copying, and they incorporate an electromagnetically-controlled device for this purpose. It embodies a stylus which moves towards the template or master as soon as the switch is set for copying and, in subsequently following the contour of the pattern, actuates electromagnetic clutches in the apron. The motion of the stylus, and hence of the cutting tool, may be said to be in two directions only, parallel to the lathe axis and perpendicular to it. Thus in order to machine, for example, a 45-deg. shoulder, the tool moves in a series of imperceptible steps and the clutches are engaged alternately in rapid succession. Quality of reproduction is conditioned not only by the direction but also by the rate of feed and this is especially to be considered when a high standard of finish is required. Thus in the copy turning of shouldered forgings, variations in the diameter of the work entail, if the rotation of the spindle is constant, variations in the peripheral speed; and a uniform surface finish can only be obtained and the tool protected if the feed rate is modified accordingly. This is achieved by adjustable stops which permit a variety of feed rates to be pre-set and synchronised with the motion of the stylus.

The stylus, which may be interchanged with others designed for particular tasks, is suitable for use with both master workpieces and templates, either of which may be accommodated in the mounting provided. Several templates can be secured in slots in a special holder which may be rotated so that a series of cuts can be taken with the minimum of setting-up. Cuts of considerable complexity are well within the capacity of the copying device. A previously machined impeller with a number of cavities not easily accessible, and the multiple template used in connection with it, were shown at the demonstration.

The scope of these lathes is much enhanced by the position of the tailstock, which is mounted on a slide in a vertical plane at the rear of the machine. The slideways of tailstock and saddle are therefore independent and the movement of the saddle is not impeded nor the capacity of the lathe limited by tailstock interference. This second slideway can also carry any number of in-feed tool slides for the simultaneous grooving, facing or undercutting of long workpieces, and thus makes possible copy turning and multiple recessing in one set-up and reduces considerably both handling and machining times. Steadies may also be fixed to the tailstock slideway and those supplied are compact and easily manipulated.

The lathe bed is of box-section and incorporates a saddle slideway with a V-groove guide at the front and a flat way at the rear, both of which are maintained in an oil flooded condition. The saddle too is of box-type construction, unweakened by the recesses necessary in earlier designs to accommodate the tailstock during short centre work. The saddle traversing rack is housed inside the trough, adjacent to the front guideway, and the leadscrew, which is a feature of the multi-purpose version of the lathe only, is situated in the hollow provided by the concave upper wall of the bed. This channel serves as an oil-bath and is a less exposed position for the leadscrew than the more conventional one at the front of the lathe bed. The saddle slideway, leadscrew and rack are shielded from swarf and dust by telescopic steel sheet guards which move with the saddle.

MULTI-PURPOSE COPYING LATHE.

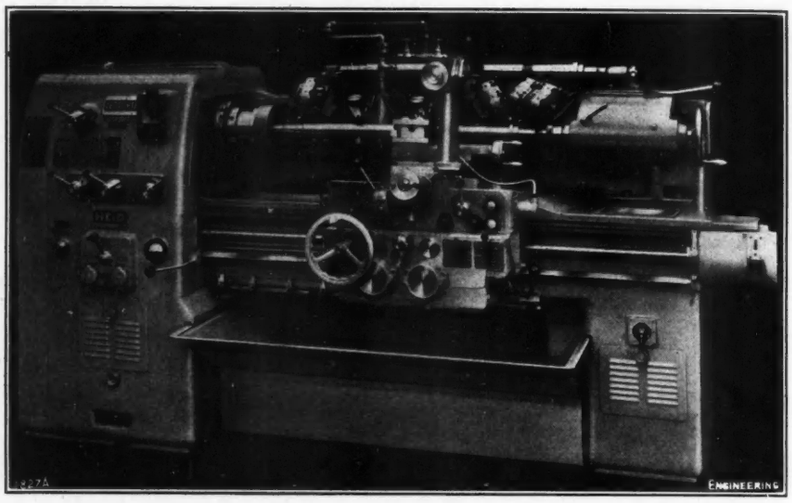


FIG. 1. COPYING LATHE, SHOWING TAILSTOCK ON SEPARATE SLIDEWAY.

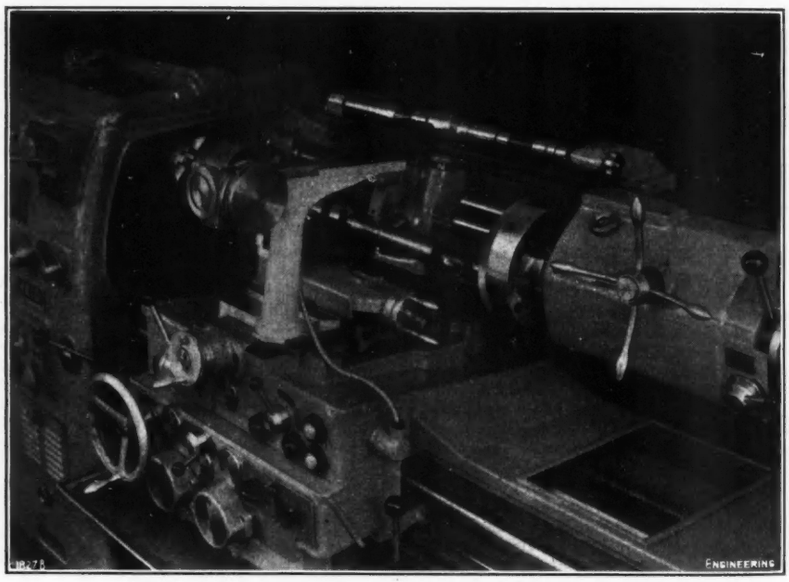


FIG. 2. LATHE WITH TURRET-TYPE TAILSTOCK.

PRE-THREADING ATTACHMENT.

Another feature designed to protect the leadscrew is a pre-threading attachment which enables threads and worms to be cut simply by means of the feed shaft and rack. Since, therefore, the leadscrew is only used for the finishing cut, its precision is retained indefinitely and the machining time is considerably reduced.

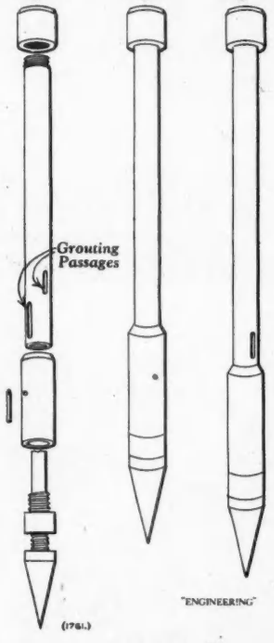
The multi-purpose lathe permits a range of 32 threads to be cut, whether metric, module, D.P. or Whitworth, varying in the case of normal Whitworth, for example, from 4 to 56 threads per inch. There are also 32 sliding and surfacing feeds which range from 0·0004 in. to 0·2200 in. per revolution and two available ranges of 18 spindle speeds—one from 22 to 1,800 r.p.m. and a special range from 31 to 2,500 r.p.m. The spindle bore is $1\frac{5}{8}$ in. and the metric taper of the spindle is No. 50. The centres are No. 4 Morse for the headstock and No. 5 Morse for the tailstock. The fixed steadies have a capacity ranging in diameter from $\frac{3}{4}$ in. to $4\frac{3}{4}$ in. The distances between centres for two alternative versions of the multi-purpose lathe are 3 ft. 3 in. and 4 ft. 11 in., the larger value being also that of the production-type lathe, which is in most respects identical with its companion. The centres are set $7\frac{1}{8}$ in. from the tailstock slideway, between which and the face-plate is a gap of $9\frac{7}{8}$ in. to accommodate work of a large diameter.

A recess between the headstock and the saddle slideways allows the telescopic bed guards to pass inside the cabinet. They therefore do not impede the saddle, and the tool rest can approach within a short distance of the main spindle. A universal relieving device and an alternative turret-type tailstock (shown in Fig. 2) add to the versatility of the machine, which can take full advantage of modern carbide-tipped tools. The gearbox, which houses both headstock gears and feed gears, is supported not by the lathe bed but by the left-hand cabinet leg. This arrangement, the absence of discontinuities in the bed and other features already noted contribute to the rigidity of these lathes which, by virtue of their simple and comprehensive design, are easily handled and capable of an extensive range of applications.

TOOL FOR DEEP-LEVEL GROUTING.

WHERE embankments have been constructed of fissured clay which has been inadequately consolidated, slips and continuous deformations are likely to occur over a period of many years. A simple and cheap method for securing stabilisation is achieved by introducing, under pressure, a stiff cement-water grout into the fissures of the clay. To assess the efficacy of this method, the Western Region of British Railways have undertaken a full-scale experiment on the long embankment near Fenny Compton station between Banbury and Leamington Spa. The method adopted differs from ordinary track grouting, inasmuch as the grout is introduced at a much deeper level, say 15 ft. to 17 ft. below running level, and at a relatively higher pressure.

Initially, difficulties were experienced due to the grout working its way upwards around the outside of the tubes used for its introduction into the



ground. To overcome this difficulty, a new form of grouting point, the components of which are shown in Fig. 1, has been developed. During driving, the grouting passages remain covered by the long collar, as shown in Fig. 2, which is fixed to the point itself by a simple dowel; in this fashion the passages are kept clear of soil which would otherwise clog them. When the required depth has been attained, a bar is lowered inside the grouting tubes and the forward nose of the grouting point is hammered further into the embankment, so uncovering the passages, as illustrated in Fig. 3. The larger-diameter collar at the top of the grouting point not only enables the point to be attached to the tubes, but also serves to create a wedge of soil which acts as a seal preventing the upward flow of grout.

The points have been driven by a simple hand-operated pile-driving frame. They can, of course, be withdrawn and re-used. The grout was introduced directly into the tubes from a small hand pump without the use of an intermediate compressor. For the clay ground at Fenny Compton, it was found that about 18 bags of cement (18 cwt.) could be forced through each point sunk. The experiment, which has so far involved driving approximately 1,500 points, has proved sufficiently successful to allow the speed restriction that had been imposed along the embankment to be abolished. Furthermore, the constant attention and fettling of the track that had previously been required have been greatly reduced and the only work now required is occasional lifting due to the continued consolidation of ashes which had been tipped into earlier slips. The cost of the deep grouting has worked out at about 8*l*. per linear foot of track (excluding the purchase price of the plant), as compared with about 50*l*. per foot that the provision of counterfort would have cost.

GROUND RESONANCE OF HELICOPTERS.

SEVERAL serious helicopter accidents have resulted from self-excited vibrations of the machine during ground running, taxying, take-off, or landing. The theory of the phenomenom and its relation to undercarriage design were discussed in a lecture on "Ground Resonance of the Helicopter," given by Mr. R. M. Howarth and Mr. C. H. Jones before the Helicopter Association of Great Britain in London on Friday, December 4. They defined ground resonance as a divergent oscillation of the helicopter on its undercarriage, in which the rotor hub moved cyclically in the plane of rotation. It could only occur in the vicinity of a natural frequency of the helicopter.

From a discussion of a theory of coupled drag-hinge and hub oscillations, the lecturers showed that, in general, a range of instability must exist for each natural frequency of the rotor mounting. The range of instability was affected greatly by the product of hub-damping and drag-hinge damping, although neither of these factors alone had a significant modifying influence. If self-excitation was likely to occur at operational rotor speeds, however, it was not usually possible to provide sufficient damping to eliminate it. A wide separation of the natural frequencies was desirable to ensure that the critical regions did not coincide with the operational rotor angular-frequency range. Model tests had confirmed these conclusions, and had also emphasised the desirability of low natural coupled frequencies of the rotor mounting since, should self-excitation occur, it was then much less violent.

Since it was impossible to assess accurately the oscillating properties of undercarriages, impedance tests were necessary, to determine the equivalent dynamic stiffness and damping constant at the rotor in the fore-and-aft and lateral directions, under a periodic force applied at the rotor axle in the plane of rotation of the rotor. The test had to be carried out over a range of applied forces at attitudes and wheel reactions corresponding to a complete take-off and landing cycle. It was usual to test at the all-up weight which was expected to be the least stable.

The lecturers then considered the effect of undercarriage design. With a single-rotor machine, the mainly-lateral and mainly-rolling modes of oscillation were the most troublesome; with tandem rotors, the mainly-torsional mode must also be considered. The stiffness and damping of the shock-absorber leg were functions of the mean axial load, frequency and amplitude. When the strut was partly compressed under a constant mean load, no periodic change in length would occur unless the periodic applied force exceeded the static frictional force; when this occurred, the stiffness of the strut was initially that of its air column and was a function of the mean axial load. The damping due to friction was inversely proportional, whereas the damping due to the air force was directly proportional, to the maximum sliding velocity of the cycle. Thus, as the maximum sliding velocity increased from zero, the total damping fell from infinity to a minimum value and then rose again. The influence of the tyre still further complicated the problem.

They then described three alternative undercarriage designs. That of the Bristol 173 Mark I was relatively flexible laterally, and had high-pressure tyres, resulting in a low yawing frequency (80 cycles per minute) and lateral frequency (60 cycles per minute). The design was such that, for rolling oscillations of the helicopter, oil passed from one main undercarriage leg to the other, giving zero stiffness but substantially viscous damping. In a symmetrical landing the system behaved as though normal separate legs were fitted. Rolling stiffness was obtained by external low-rate steel coil springs, and also by gravity effect. The gravity stiffness dropped to zero when the helicopter was on the point of leaving the ground. The coupled rolling frequency remained at about 120 cycles per minute throughout take-off and landing, i.e., about half the operating frequency, and the product of undercarriage and drag-hinge damping was sufficient to eliminate instability. In a one-wheel landing, the tendency to bounce from one wheel to another was reduced, and the fundamental bouncing frequency was in any case lower than that of the rolling mode of oscillation. The system became more stable during taxying. A tyre burst could, however, lead to high lateral stiffness and to ground resonance of the helicopter.

In another undercarriage design, a high rolling stiffness was employed, e.g., by use of a torsion bar linking the main wheel units, and the frequency of the coupled modes were separated so that the mainly-rolling frequency was well above rotor frequency, and the mainly-lateral frequency well below half rotor frequency. An undercarriage of this type would become less stable as taxying speed increased. A soft tyre resulting from a puncture would also tend to reduce the stability, owing to a reduction in lateral and vertical stiffness at the wheel. The system was, however, safe in the event of a burst tyre. There were possibilities of bouncing resonance arising from a one-wheel landing, and in general this undercarriage was less docile than the first one, although for ship-board use a high rolling stiffness might be essential.

In the third design, as used in most small helicopters, the lateral tyre stiffness and vertical stiffness of the oleo and tyre combination were relied on to give a sufficiently high rolling frequency and a sufficiently low lateral frequency. The system was likely to give trouble with punctured and burst tyres, and following heavy rolled landings. Careful matching of tyre and oleo characteristics was necessary to avoid a decrease in stability with amplitude.

AIR-CIRCULATED DRYING OVEN FOR PRINTED STEEL SHEETS.

THE decoration of steel and tinplate sheets in the flat condition, before they are worked-up into boxes or containers, has been practised for many years. Briefly, the process involves either applying a patterned or worded coating by means of a printing machine, or else covering the surface of the sheet with a single colour by using a roller coating machine. The coatings may be for decorative or protective purposes, or both.

With small containers the practice is to apply a number of individual impressions to each sheet, which is then divided by gang-slitting machines ready for forming into the required shape. Each coating is applied separately, and requires to be stoved before any further work can be done. In many cases, both sides of the sheet are coated, the one carrying a decorative printing, and the other a protective lacquer. For drying the coatings, a conveyor-type oven is used, the sheets, on edge, being carried through heating and cooling zones automatically, as shown in Fig. 3, on page 781. Three different sheet-carrier spacings are normally used, the carriers being pitched at 1¼ in., 1 in., or ¾ in.; the sheets are thus spaced at 9½, 12, or 16 per foot of conveyor length.

Until recently, the largest sheet which could be processed by this method had a maximum width of 36 in., a limitation imposed by the available printing and coating machines. The question of applying the conventional method to larger sheets has, however, been studied closely in the last few years, particularly by the steel drum industry. As a result, machines for printing and roller-coating sheets up to 72 in. wide by 16 I.S.W.G. have been developed and installed in the United States and there is now a production line of this capacity working in Great Britain. It is installed at the Bristol works of Rheem Lysaght, Limited, and is the first of its size outside the United States.

The equipment comprises printing, roller-coating, feeding, and unloading machines of American origin,

DRYING OVEN FOR PRINTED STEEL SHEETS.

STORDY ENGINEERING, LTD., WOLVERHAMPTON.

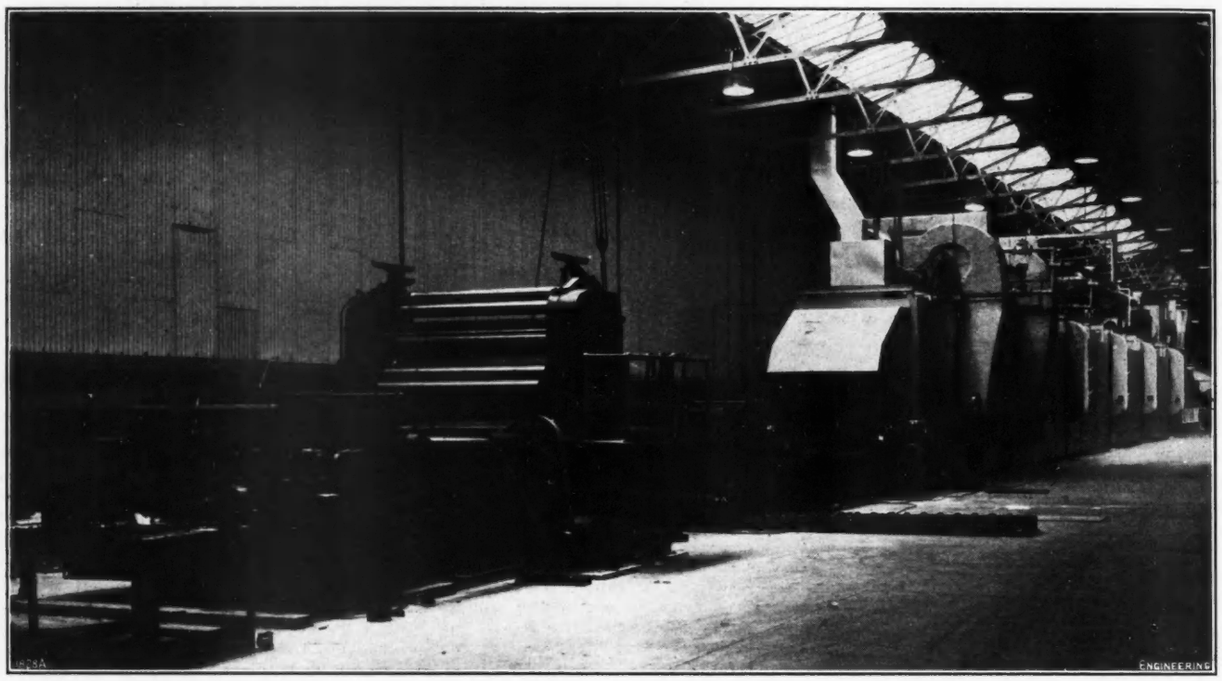


Fig. 1. General View, Showing Printing Machine, Roller Coating Machine, and Feeding Machines.

and a continuous drying oven of the air-circulated type, designed and built by Stordy Engineering, Limited, Goldthorn Hill, Wolverhampton. This firm were also responsible for the transfer machine between the roller coater and the oven conveyor. The units are installed in tandem, and the flow of material through the complete production line, which is 300 ft. long, is automatic. The maximum size of sheet which can be handled is 72 in. by 45 in., and smaller sizes can also be processed, in some cases up to a maximum speed of 4,500 per hour. Fig. 1 shows the complete installation from the feed end. Two feeding machines are provided, one for the printing machine, which is visible in the foreground, and one for the roller coating machine. It is thus possible to use the equipment for either printing or coating, by withdrawing one or other of the machines from service. Arrangements have also been made for the printing and coating machines to be used together if required. Control of the drives to the two machines is effected by the stove conveyor drive, thus ensuring that all the items in the line are correctly in phase.

Sheets are brought to the machine in packs, on pallets transported by fork-lift trucks, and loaded on to a carriage, which is then run into the feeding machine, and raised into the working position, ready for operation. The carriage of the roller-coating machine feeder can be seen in Fig. 1, in the withdrawn position, ready to receive a pack of sheets. When the sheets have been elevated to the working position, they are separated by an air-blast, and fed forward, one at a time, by suction cups on feed arms, the feeding-machine table being progressively raised as the pack of sheets is reduced in height. If the plant is being run for printed work, the sheets are fed from the pack to a short chain conveyor with pusher "dogs," which passes them to the printing machine, where they are centred by magnetic pulleys. On the delivery side of the printing machine the sheets are taken by a belt transfer machine, with belt faces of special form to prevent slip, and passed to a second "dog" conveyor, which leads them to the roller coating machine. When printed work is being run, the rollers of the coating machine are gapped open, and the sheets pass through the idle machine. Conversely, if coating only is required, the coating machine feeder is brought into use, and the transfer belt is retracted. The printing machine is then idle. Normally, either the printing machine or the roller coater is used, the appropriate feeder being brought into operation, but the line is so arranged that both machines can be used in the same cycle if required. It may, for example, be necessary to apply a varnish coat to the printed surface; in this case the two machines operate in sequence.

Fig. 2. Feed End.

Conveyor Oven.

After leaving the coating machine, the sheets pass to a separately-driven transfer machine, which feeds them to the oven conveyor. This machine is retractable, to allow access to the coating-machine rollers for cleaning and maintenance purposes. The drying oven has a heating section 170 ft. long, the body being 11 ft. high and 8 ft. in overall width. Following the oven is a cooling section, 43 ft. long.

The oven is arranged for town-gas firing, the gas consumption under normal operating conditions being from 20,000 to 22,000 cub. ft. per hour. It has six separate heating zones, which consist, basically, of a combustion chamber and a means of circulating the heated air round the sheets as they

DRYING OVEN FOR PRINTED STEEL SHEETS.

STORDY ENGINEERING, LTD., WOLVERHAMPTON.

FIG. 3. COOLING SECTION AND UNLOADING END.

pass along the conveyor. The first two zones are designed to handle the total cold-work load plus their own radiation losses; the centre three zones cater for radiation losses only, and the sixth, or final zone is heated to cover radiation losses plus the heating of the whole of the fresh air supply, which is drawn in under the unloading end hood. The fresh air thus drawn in is first used in zone six, and then progressively re-circulated back through the preceding five zones to the loading end of the oven, where it is discharged to the outside atmosphere by a centrifugal-type exhaust fan. This fan pulls from a duct above the loaded conveyor, the exhaust system also coupling into the loading end hood, so that spillage of hot, or fume-laden air into the shop is eliminated. The solvents used in the decorative or protective finishes are driven off in the first zone, and the exhaust fan discharges them outside the shop at once.

The combustion chambers are mounted on top of the oven, and air-supply ducts are arranged below the top conveyor track, with distribution nozzles of special design extending the full width of the oven. These nozzles are individually adjustable to enable correct air distribution to be achieved in the work chamber. Fig. 2 shows the feed end of the oven; some of the external ducting, fans, and combustion chambers are visible. There are six combustion chambers, each with its own air-circulating equipment, and each having individual thermostatic control. The first two heating zones are each fitted with two very large capacity multivane-type circulating fans, while each of the remaining zones has one circulating fan. The temperature controls are Negretti and Zambra mercury-in-steel pattern, the measuring bulbs being of the averaging type. The gas controllers are compressed-air operated, and work in conjunction with reverse-acting, spring-loaded diaphragm valves fitted in the main burner line to each combustion chamber, the design of the valves permitting of "floating" control.

Each combustion chamber is fitted with flame-failure control, which has a delay-purge feature, so that the zone is thoroughly purged before gas can reach the combustion chamber. The flame-failure shut-off valves are the control valves mentioned above, control being effected by a small solenoid valve in the compressed-air supply line to each diaphragm chamber. Shut-off valves are also incorporated in the pilot gas lines, these valves being of the diaphragm-relay type in zones one and two, and solenoid type in the remaining zones. Air-flow switches are wired into all the flame-failure circuits, to give fan-failure protection to the combustion chambers. Spark ignition is provided for each pilot line.

As the operating temperature may at times be as high as 450 deg. F., the fan runner gear is of the ring-oiled, white-metal lined type, the inner bearing of each fan being water cooled. All the fans are driven through V-belts by squirrel-cage protected-type motors. In addition to the re-circulating ducting previously mentioned, bleed connections are taken from the main circulating system in zones one and two to supply heated air to the bottom return section of the oven conveyor. The sheet carriers are thus heated before the printed or coated sheets are deposited on them. The possibility of unequal drying as a result of the sheets resting on cold carriers is thus obviated.

After leaving zone six of the oven, the sheet conveyor carries the sheets into a cooling section, which is separated from the oven by a small gap. The cooling section is provided with 26 propeller-type cooling fans, mounted below the top conveyor track, and delivering large volumes of air at high velocity normal to the sheets as they are moved along. Air for cooling is drawn from the shop through large apertures in the sides of the lower conveyor track housing, the openings being protected with expanded metal. Two-thirds of the length of the cooling section is sheeted in, and three large exhaust fans are provided to exhaust the cooling air to the outside atmosphere. Fig. 3 shows the cooling section, and the exhaust-fan ducts leading through the roof are clearly visible. Arrangements have been made for exhausting all or part of the cooling air as required; in cold weather some or all of this heated air can be released to the shop to assist in space heating.

The oven casing consists of specially-designed removable insulated panels, carried on a steel structure, and arranged with a minimum of through metal from inside to outside, in order to give a high overall thermal efficiency. Insulated access doors are provided at frequent intervals on both sides of the oven. The supply and re-circulating ducting has been manufactured from heavy galvanised sheet, and the conveyor trays have been painted and stoved. The possibility of trouble due to rust has thus been reduced to a minimum.

CONVEYOR AND ELECTRONICALLY-CONTROLLED DRIVE.

The conveyor chain comprises four strands of bush roller chain, with finger-plates to carry the sheet trays. The finger-plates have been designed with a profile which ensures that each sheet is carried at a slight angle from the vertical, and that it cannot ride forward and make contact with the back of the preceding sheet. The carrier trays are of riveted and welded construction, being fabricated from light mild-steel flats, and are riveted to the conveyor-chain finger-plates. A light steel-bar track, supported on cast-iron brackets, and having special expansion joints at frequent intervals, carries the conveyor chains through the oven and cooling section.

The conveyor is driven from the loading end, through a Heenan and Froude eddy-drag coupling, and a single-reduction worm gearbox, from a squirrel-cage protected-type motor. A chain drive leads from the eddy-drag coupling to the worm gearbox, the output shaft of which is coupled directly to the main drive shaft of the conveyor. Infinitely-variable control of the conveyor speed is effected by controlling the eddy-drag coupling electronically. To ensure complete synchronisation between the printing and roller coating machines and the oven conveyor, the drive motor of the printing machine is electronically enslaved to the conveyor drive, and a layshaft is taken from the eddy-drag coupling to the coating machine. The drive control circuit also incorporates a non-overloading feature, which can be set for any predetermined value, and acts in the same way as a shear-pin.

The conveyor shafts are carried in heavy-duty ball-bearing plummer-blocks, the shaft at the unloading end being provided with adjustable tension gear, controlled by hand-wheels from either side. In addition, there is a rack-and-pinion weight-loaded tension gear at the drive or loading end, to take up any slack in the conveyor, and to ensure that both sides are at approximately the same tension. Full electrical interlocking is provided on all the units of the production line, so that the correct starting sequence must be followed, and micro-switches are fitted at all possible trouble points. Tripping of one of these switches cuts out the conveyor drive, and applies an electromagnetic brake to bring it quickly to rest.

After the sheets have passed through the oven and cooling section, they are delivered, coated side downward, on to a take-off belt, with independent drive. This leads to a pile-stacker. Provision is also made for delivering the sheets with the coated side upward if required, as would be the case where subsequent runs through the line were needed. For this purpose there is a turn-over device, which is basically a star-wheel. It is driven by an extension shaft from the rear-end conveyor shaft, special precautions having been taken to overcome backlash due to the out-of-balance effect. The turn-over device can be retracted below the take-off belt when not in use.

DYKES REPAIRED WITH SAND-ASPHALT.—Among the Dutch islands which suffered great damage in the floods last January was that of Goeree-Overflakke; 15 miles of the outer dyke have been repaired in a period of five months. The dykes have been built of sand dredged from the flats lying off-shore and pumped directly to the construction site to be discharged between two foot walls. The sand dyke was then graded and provided with a sand-asphalt carpet on the seaward side and with clay on the landside. The sand-asphalt contained only 8 per cent. bitumen and 8 per cent. filler; this will protect the sand structure until a final coat of asphalt concrete can be applied.

THE LATE MR. H. LEDWARD.—We regret to record the death of Mr. Hugh Ledward, which occurred at Kingston, Surrey, on Thursday, December 3, at the age of 69. Mr. Ledward received his technical education in Germany and at Finsbury Technical College. He was then associated with the laying of the tramway system in Moscow and, after much hardship during the Bolshevik revolution, was appointed British Vice-Consul at Vladivostok. In 1927 he joined the Edison Swan Electric Co. as personal assistant to the chairman and later became manager of the Export and Radio Departments. He was afterwards engaged by the British Thomson-Houston Co. to watch over their world lamp interests. For a short time after the 1939-45 war he served with the Control Commission in Germany, with the rank of brigadier, and then again with the British Thomson-Houston Co., until his retirement in 1951.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

UNIVERSITY APPOINTMENTS AT GLASGOW.—Mr. J. B. Mavor, chairman of Mavor and Coulson, Ltd., Glasgow, and of the North British Locomotive Company, Ltd., has been appointed assessor to the Rector of Glasgow University (Dr. T. J. Honeyman). The Senate have also appointed Professor James Small, of the James Watt chair of mechanical engineering, as an assessor on the Court for four years in place of Professor J. W. Cook, of the chair of chemistry, whose term of office has expired.

CLYDE LIGHTHOUSE RATES.—Mr. F. W. Robertson, chairman of the Clyde Lighthouses Trust, gave a warning at the annual meeting of the Trust, on December 2, that, although the rates were increased by 25 per cent. less than two years ago, it might be necessary to apply for a further increase in order to build up sufficient funds to meet emergencies. He doubted whether adequate provision was being made to cover such eventualities as dredging expenditure or the heavy outlay in connection with beacons or buoys, or in regard to plant and workshops. The net registered tonnage of ships on which dues were paid during the year was 12,317,988, an increase of 974,466 on that of the preceding year. Mr. Robertson was re-appointed chairman for the ensuing year, and Lieut.-Col. Hugh Campbell deputy chairman.

RADIO UNIT FOR MINE RESCUE WORK.—The Scottish Divisional Coal Board are installing a new radio unit at Coatbridge rescue station which will enable rescue vans to keep in constant touch with the home station in the event of an emergency. The Post Office have made a wave band available. The power to be used will give an effective range of 20 miles, which will cover most of the collieries in Lanarkshire, Stirlingshire, and West Lothian.

GARDENSTOWN HARBOUR.—The Gardenstown harbour trustees have approached the Law and Finance Committee of the Banffshire County Council regarding the possibility that the Council might take over a new harbour if it were built. The estimated cost of the harbour is 200,000*l*.

PROPOSED SMOKELESS ZONES.—The Scottish Fuel Efficiency Committee report that about a dozen local authorities in Scotland, including the corporations of Glasgow, Edinburgh and Aberdeen, are now considering proposals for smokeless zones as a result of representations made by the committee and the Smoke Abatement Society.

THE ENCOURAGEMENT OF HIGHER PRODUCTIVITY.—The Glasgow Productivity Committee of the British Productivity Council are to organise a "circuit scheme" of visits between factories in the Glasgow area by teams representing management, technicians, and tradesmen. The committee seek to encourage by this scheme exchanges of visits between firms of all kinds, whether they are in competition or not.

CLEVELAND AND THE NORTHERN COUNTIES.

THE TYNE TUNNEL.—Mr. Hugh Molson, M.P., Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, received, on December 7, a deputation from the Tyne Tunnel Joint Committee, representing the Durham and Northumberland County Councils. The deputation stressed the urgency of the need to complete the Tyne Tunnel scheme by the construction of the vehicular tunnel, both to ease the transport problems of heavy industry on both banks of the Tyne and to enable general road planning of the two counties to proceed. Mr. Molson agreed that the scheme was necessary, and promised that it would be fitted into the future programme of road works as soon as possible.

THE FUTURE OF HORDEN COLLIERY.—The Durham Coal Board have posted notices at the pithead at Horden Colliery regarding the future of the colliery, and to allay local fears that redundancy was to be expected. Some Horden miners have already left to work in the Midlands. The Board stated that there was no reason for face workers to leave. Any displacements at Horden during the next few years would be the result of re-organisation to improve efficiency and would involve only elderly and unfit men; there would be no redundancy among face workers or among men willing to be upgraded. The statement added that, though the Low Main seam at Horden would be worked out in about ten years, higher seams were being opened up and major developments at nearby collieries would employ men who were not needed at Horden. Horden Colliery employs 4,000 men and boys and is one of the biggest in the country, with a weekly output of about 22,000 tons.

PROGRESS AT LACKENBY STEELWORKS.—Dorman Long & Co., Ltd., Middlesbrough, have put into operation a third and a fourth furnace at their new Lackenby steelworks in North Yorkshire. A fifth furnace will be ready in the New Year. The melting plant at the firm's Britannia Works, Middlesbrough, has now been closed and the men are being transferred as required to Lackenby. The Britannia plant started nearly 70 years ago and has produced about 10,750,000 tons of steel. Rolling of structural sections will continue at Britannia works until the new mills at Lackenby are ready, which will probably be in about three years' time.

SHIPBUILDING ON THE WEAR.—The first half of a tanker of 18,000 tons, being built by John Crown & Sons, Sunderland, for Rolf Wigand of Norway, is to be launched on December 31. The ship is being built in halves as the berth is not long enough to accommodate the ship as a whole. On December 21, William Pickersgill & Sons will launch the first of two inshore minesweepers that they are building for the Royal Navy.

TEES SHIPPING.—The Tees Conservancy Commission report that, during the 12 months ended October 31, the number of ships clearing the river was 4,331, the highest figure since 1914. The vessels aggregated 4,658,234 net tons, also the highest figure on record. The increase concerns mainly vessels in the coasting trade, and liner traffic from European and distant ports. During the 12 months, imports into the river amounted to 4,337,574 tons, including more than 2,900,000 tons of ore.

LANCASHIRE AND SOUTH YORKSHIRE.

INDUSTRIAL ADMINISTRATION.—The Senate of Manchester University and the governors of the College of Technology have resolved to establish a professorial chair in Industrial Administration. The decision has been reached because the need and the possibility of education and training for management have clarified since 1918, when the Department of Industrial Administration was established. It is felt that lines of further progress are now emerging. The College hopes that a candidate with experience of industrial management at a high level will come forward, despite the discrepancy between the rates of remuneration customary in industry and in the academic field. The holder of the chair will be expected to maintain practical contact with industry, and facilities will be afforded for him to undertake some consulting work.

PRECISION CASTINGS FOR AIRCRAFT.—Hadfields, Ltd., Sheffield, have made headway with a 100,000*l*. development plan for the production of precision castings for the aircraft and allied industries, by the lost-wax process. The managing director, Mr. Harold Humphries, states that the firm have been working the process under licence for about two years, at first in a research stage, and then in the pilot stage. Now they are ready for full production, with new plant and equipment.

COLLIERY RECORDS.—Brodsworth colliery, in the Doncaster area, has the distinction of being the first colliery to raise a million tons of coal this year. Now the aim is to reach 1¼ million tons before Christmas. By December 5, the total was 1,234,479 tons. Another South Yorkshire colliery, New Stubbin, has achieved its highest output since December, 1937. Kiveton Park, in the week ended December 5, produced a record output of 13,206 tons. The pit was opened nearly 50 years ago.

THE MIDLANDS.

GAS FROM RESIDUAL OIL.—During a visit to two works of the West Midlands Gas Board on December 4 the Minister of Fuel and Power, Mr. Geoffrey Lloyd, M.P., was shown plant for the production of gas from black oil, a petroleum refinery residue. Considerable experimental work has been done in the West Midland Board's area on the utilisation of this residual oil, and plant is now in operation for the production of gas on a small scale. The gas is mixed with the normal output of the gas works, and fed into the mains.

WITHDRAWAL OF RAILWAY PASSENGER SERVICES.—Sixteen railway passenger stations between Nottingham and Market Harborough, and Leicester and Grantham, were closed for traffic on December 6. The stations affected served rural communities, and the London Midland Region of British Railways have stated that, for some time, passenger traffic has been negligible. The lines are being kept open for goods traffic, and goods facilities will be retained at some of the stations.

PART-TIME DAY RELEASE FROM INDUSTRY FOR FURTHER EDUCATION.—A conference was held at Birmingham on December 4, under the auspices of the British Association for Commercial and Industrial Education, to discuss the question of part-time day release for industrial workers. Sir Arthur P. M. Fleming (Associated Electrical Industries, Ltd.), said that the scientist and technologist should receive a background of education which would promote the development of the whole man, as distinct from the narrow specialist. He added that, in his own organisation, the principle of day-release for further education applied to every grade of employee, regardless of age, sex or status, and he appealed for co-operation between employers and local authorities to provide similar opportunities. Sir Hugh Chance (Chance Brothers, Ltd.), said that many firms encouraged technical training for apprentices, but asked if they could afford to ignore the needs of the unskilled and semi-skilled. By co-operation, small firms could do what some of the larger concerns had done.

PROGRESS ON THE LOWER AVON NAVIGATION.—At the annual meeting of the Lower Avon Navigation Trust, held at Evesham on December 4, Mr. C. D. Barwell, chairman of the Trust, said that a gift of 4,500*l*. had made it possible for further work to be undertaken. It was decided to use the money for rebuilding one of the two water gates, or navigation weirs. A survey of these two gates, which are at Cropthorne and Pershore, respectively, will be carried out in January, 1954, to decide which shall be repaired.

TRANSFER OF FACTORY.—The Standard Motor Company, Ltd., are to take over the factory of Modern Machine Tools, Ltd., in Maudslay-road, Coventry, for use in supplying spare parts, particularly for tractors. Modern Machine Tools, Ltd., will move to an existing factory in Gosford-street, Coventry, and will take over office accommodation in Broadgate House, in the city centre. The moves will take place early in the New Year.

THE LATE MR. A. DUDLEY EVANS.—The death has been announced, at the age of 82, of Mr. A. Dudley Evans, who was secretary of the Birmingham Iron Exchange for 42 years. He retired from this position in 1950, but remained secretary of the Exchange Buildings Company, Ltd., until a few months ago.

SOUTH-WEST ENGLAND AND SOUTH WALES.

SWANSEA AIRPORT.—After months of deliberation, Glamorgan County Planning Committee have granted permission for Swansea Corporation to retain Fairwood Common as a municipal aerodrome for civilian use. The decision was reached in spite of strong opposition from farmers and commoners, and from the Gower Rural Council, in whose area the aerodrome will be sited.

EXPORT ORDER FOR CANADA.—A Canadian order worth about 750,000 dols. has been obtained by the Aluminium Wire & Cable Company, of Port Tennant, Swansea, for the supply of steel-cored aluminium conductor to the British Columbia Electric Railway Company, for delivery in the first half of next year.

EMPLOYMENT IN SOUTH WALES.—The drift of labour from the Welsh basic industries to less arduous work has now been reversed, according to Mr. J. A. Chapman, secretary and a director of Partridge Jones & John Paton, Ltd., speaking at a staff dinner at Newport. During the past five years, he added, the company had rebuilt five furnaces, at a cost, with other additions and improvements, of more than 350,000*l*. It may be noted that Mr. Dennis H. Morgan, deputy controller of the Board of Trade in Wales, said recently that, during the past few years, when the Board had been trying to bring new industry into Wales, 137,000 new jobs had been created in Welsh factories. Between 400 and 500 new firms had come to Wales.

STEEL OUTPUT AT EBBW VALE.—Three output records were set up in the Ebbw Vale steel works of Richard Thomas & Baldwins, Ltd., in the week ended December 4. In the open-hearth department, the output rose to 6,636 tons, beating by 436 tons a record which had been set up only in the previous week. The total steel output, Bessemer and open-hearth departments, in the week was 12,665 tons, an increase of 768 tons over the previous highest figure. In rolling 12,607 tons during the week, the blooming mill exceeded by 414 tons the previous highest total. All three records were set up in the course of a normal working week.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF PRODUCTION ENGINEERS.—*North-Eastern Section:* Monday, December 21, 7 p.m., Neville Hall, Newcastle-upon-Tyne. Film Evening. *Sheffield Graduate Section:* Monday, December 21, 7 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield. Film Evening. *Shrewsbury Section:* Wednesday, December 30, 7.30 p.m., Technical College, Shrewsbury. Film Evening. *Coventry Graduate Section:* Tuesday, January 5, 7.30 p.m., Hare and Squirrel Hotel, Cow-lane, Coventry. Film Evening. *Nottingham Section:* Wednesday, January 6, 7 p.m., Victoria Station Hotel, Nottingham. "The Production Engineer and His Relationships," by Mr. J. H. Bingham. *Wolverhampton Section:* Wednesday, January 6, 7.15 p.m., Wolverhampton and Staffordshire Technical College, Wolverhampton. "Application of Hydraulic Power as an Aid to Productivity," by Mr. F. B. Levetus. *South Wales and Monmouthshire Section:* Thursday, January 7, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Increased Productivity by the Use of Compressed Air," by Mr. C. M. P. Willcox. *Eastern Counties Section:* Friday, January 8, 7.30 p.m., Diocesan Hall, Tower-street, Ipswich. "The Production of Woven Artificial Silk Fabrics," by Mr. E. H. Boas and Mr. N. Ray. *Western Graduate Section:* Monday, January 11, 7.30 p.m., Grand Hotel, Broad-street, Bristol, 1. "Management and the Law," by Mr. H. Jost.

INSTITUTE OF FUEL.—Tuesday, December 22, 5.30 p.m., Institution of Mechanical Engineers, Storey's-gate, St. James's Park, S.W.1. "Festival Hall Heat Pump," by Mr. P. E. Montagnon. *South Wales Section:* Friday, January 8, 6 p.m., Technical College, Bridgend. "Extension at Llandarcy," by Mr. F. V. M. Bell. *North-Eastern Section:* Monday, January 11, 6.30 p.m., King's College, Newcastle-upon-Tyne. "The Calorific Value of Coal," by Mr. J. Brown.

JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 1, 7 p.m., Townsend House, Greycoat-place, S.W.1. Films, introduced by Mr. S. G. Clark. *Midland Section:* Wednesday, January 6, 7 p.m., James Watt Memorial Institute, Birmingham. Chairman's Address on "Brewing and Distilling," by Mr. T. F. Luck. *Institution:* Friday, January 8, 7 p.m., Townsend House, Greycoat-place, S.W.1. "A Modern Vehicle-Actuated Detector and Its Development," by Mr. H. J. N. Riddle. *Sheffield Section:* Monday, January 11, 7.30 p.m., Livesey Clegg House, Union-street, Sheffield. "Clean City Air: An Engineer's Problem," by Mr. James Law.

INSTITUTION OF ELECTRICAL ENGINEERS.—*South Midland Centre:* Monday, January 4, 6 p.m., James Watt Memorial Institute, Birmingham. Discussion on "Technical Education of Other Than National Certificate Students," opened by Mr. J. Ashmore and Mr. D. I. Meyrick. *Mersey and North Wales Centre:* Monday, January 4, 6.30 p.m., Royal Institution, Colquitt-street, Liverpool. "Electronic Telephone Exchanges," by Mr. T. H. Flowers. *District Meeting:* Monday, January 4, 6.30 p.m., Crown and Anchor Hotel, Ipswich. "Modern Developments in Atomic Energy," by Dr. T. E. Allibone. *Measurements Section:* Tuesday, January 5, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. (i) "A Scaling Unit Employing Multi-Electrode Cold-Cathode Tubes," by Mr. K. Kandiah; (ii) "A Sensitive Pulse Triger Circuit with a Stable Threshold," by Mr. K. Kandiah; and (iii) "The Development of a Neutron Spectrometer for the Intermediate Energies," by Mr. F. S. Goulding and others. *North-Western Centre:* Tuesday, January 5, 6.15 p.m., Engineers' Club, Albert-square, Manchester. "The Co-ordination of Insulation of High-Voltage Electrical Installations," by Mr. J. S. Cliff. *North Midland Centre:* Tuesday, January 5, 6.30 p.m., Offices of the Yorkshire Electricity Division, 1, Whitehall-road, Leeds. "Voltage Transformers and Current Transformers Associated with Switchgear," by Mr. W. Gray and Mr. A. Wright. *Southern Centre:* Wednesday, January 6, 6.30 p.m., Offices of the South Eastern Electricity Board, Hove. "The Operation of Power Transformers," by Mr. E. T. Norris. *Institution:* Thursday, January 7, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Parsons Memorial Lecture on "Continuity of Electricity Supply," by Mr. H. Leyburn.

INSTITUTION OF MECHANICAL ENGINEERS.—*North-Eastern Branch:* Monday, January 4, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Annual General Meeting. *London Graduates' Section:* Tuesday, January 5, 6.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Modern Thermal Power Stations," by Mr. R. C. Nicoll and Mr. J. Griffin. *Institution (Internal Combustion Engine Group):* Friday, January 8, 5.30 p.m., Storey's gate, St. James's Park, S.W.1. (i) "An Experimental Investigation into the Effect of Fuel Addition to the Intake Air on Performance of a Compression-Ignition Engine," by Mr. W. T. Lyn; and (ii) "The Effect of Auxiliary Fuels on the Smoke-Limited Power Output of Diesel Engines," by Mr. L. D. Derry, Dr. E. M. Dodds, Dr. E. B. Evans and Mr. D. Royle. AUTOMOBILE DIVISION.—*Scottish Centre:* Monday, December 21, 7.30 p.m., Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, C.2. "The Small High-Speed Two-Stroke Engine," by Dr. J. C. Morrison. *London:* Tuesday, January 12, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. "Two-Stroke Automotive Compression-Ignition Engines," by Professor Hans List.

INSTITUTION OF THE RUBBER INDUSTRY.—*North-Eastern Section:* Monday, January 4, 7 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Rubber and Ships," by Dr. W. J. S. Naunton. *Midland Section:* Monday, January 11, 6.45 p.m., James Watt Memorial Institute, Birmingham. "What the Aircraft Manufacturer Wants from the Rubber Industry," by Mr. J. H. Cork. *Preston Section:* Monday, January 11, 7.15 p.m., Bull and Royal Hotel, Church-street, Preston. "The Role of Latex in the Rubber Industry," by Mr. E. W. Madge. *Leicester Section:* Wednesday, January 13, 7.30 p.m., Bell Hotel, Leicester. "Extruders and Extrusion," by Mr. H. C. Harrison.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Sheffield Branch:* Monday, January 4, 7.30 p.m., Sheffield College of Commerce and Technology, Pond-street, Sheffield. "Examples of Loam Moulding as Applied to Production of Pump Castings and Impellors," by Mr. E. Clipson. *Lincolnshire Branch:* Thursday, January 7, 7.15 p.m., Lincoln Technical College, Lincoln. "Aluminium Pattern Equipment by the Pressure Cast Plaster Process," by Mr. D. H. Potts. *Scottish Branch:* Saturday, January 9, 3 p.m., Royal Technical College, Glasgow. "Core Assembly as a Production Aid to the Jobbing Foundry," by Mr. E. H. Beech and Mr. J. Hoyes. *Newcastle Branch:* Saturday, January 9, 6 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. "Residual Stresses in Castings," by Dr. R. N. Parkins. *West Riding of Yorkshire Branch:* Saturday, January 9, 6.30 p.m., Technical College, Bradford. "Aluminium Casting Alloys," by Mr. R. Mercer.

INSTITUTION OF CIVIL ENGINEERS.—*Works Engineering Division:* Tuesday, January 5, 5.30 p.m., Great George-street, S.W.1. "Swedish Underground Hydro-Electric Power Stations," by Mr. J. F. Hagrup.

REINFORCED CONCRETE ASSOCIATION.—Tuesday, January 5, 6.45 p.m., College of Technology, Sackville-street, Manchester. "Concreting Methods and Machinery," by Mr. A. P. Lambert. Wednesday, January 6, 6.30 p.m., Liverpool Engineering Society, 9, The Temple, 24, Dale-street, Liverpool. "Concreting Methods and Machinery," by Mr. A. P. Lambert.

INSTITUTE OF METALS.—*Oxford Local Section:* Tuesday, January 5, 7 p.m., Cadena Café, Cornmarket-street, Oxford. "Industrial Methods of Electroplating," by Dr. G. E. Gardam. *Institute:* Wednesday, January 6, 10.30 a.m., Birmingham University, Edgbaston, Birmingham. Discussion on "Lubricants for Metal-Working Operations in the Non-Ferrous Metals Industries." *London Local Section:* Thursday, January 7, 6.30 p.m., 4, Grosvenor-gardens, Westminster, S.W.1. "The Rogerstone Strip Mill," by Mr. F. King.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Tuesday, January 5, 7 p.m., Royal Society of Arts, John Adam-street, Adelphi, W.C.2. "Transmission Equipment and Bearings," by Mr. F. J. Walters. *Edinburgh Branch:* Tuesday, January 5, 7 p.m., 25, Charlotte-square, Edinburgh. "Power Factor Correction," by Mr. Hugh Ferguson. *Southampton Branch:* Wednesday, January 6, 7.30 p.m., Polygon Hotel, Southampton. "History of Southampton's Water Supply," by Mr. Joseph Hawksley. *Peterborough Branch:* Thursday, January 7, 7.30 p.m., Offices of the Eastern Gas Board, Church-street, Peterborough. "Industrial Uses of Magnetic Power," by Mr. G. T. Hawker.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*London Section:* Wednesday, January 6, 6.30 p.m., London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. "Engineering Design of Very-High-Frequency Multi-Channel Telephone Equipment," by Mr. W. T. Brown. *Scottish Section:* Thursday, January 7, 7 p.m., The University, Edinburgh. "Radio Astronomy," by Mr. H. Seddon. *North-Western Section:* Thursday, January 7, 7 p.m., College of Technology, Sackville-street, Manchester. "The Manchester University Computor," by Mr. D. B. G. Edwards.

TELEVISION SOCIETY.—Wednesday, January 6, 6.45 p.m., Film House, Wardour-street, W.1. "Marconi Television O.B. Unit," by Mr. C. Carrington.

INSTITUTION OF SANITARY ENGINEERS.—Thursday, January 7, 6 p.m., Caxton Hall, Westminster, S.W.1. Presidential Address by Mr. E. H. Vick.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, January 8, 6.45 p.m., Engineers' Club, Manchester. Discussion on "Training Designer-Draughtsmen."

PERSONAL.

MR. J. FOSTER PETREE will retire on December 31 from the editorship of ENGINEERING, to which he was appointed on March 1, 1939, jointly with MR. CHARLES COOPER. MR. COOPER, who joined the staff of ENGINEERING in 1897, relinquished executive editorial direction at the end of 1949, but is still a managing director. MR. PETREE also will continue as a member of the board of directors. His successor as Editor will be MR. F. B. ROBERTS, M.B.E., who has been chief assistant editor since January, 1950.

HIS GRACE THE DUKE OF NORFOLK and THE RT. HON. THE EARL OF ATHLONE have accepted election as Vice-Presidents Emeriti of the Royal Sanitary Institute.

PROFESSOR N. F. MOTT, F.R.S., is to succeed SIR LAWRENCE BRAGG in the Cavendish Chair of Experimental Physics at the University of Cambridge.

DR. S. G. HOOKER, chief engineer of the engine division and a director of the Bristol Aeroplane Co. Ltd., has been appointed a director of the Bristol Aeroplane Company of Canada, Ltd.

MR. J. R. HARDING, B.Sc. (Eng.), M.I.E.E., has been appointed assistant general manager of Pirelli-General Cable Works, Ltd. Magnet House, Kingsway, W.C.2.

MR. W. G. THOMAS, M.Inst.F., has been elected a director of Radiovisor Parent Ltd., 1, Stanhope-street, London, N.W.1. Mr. Thomas is also managing director of Bailey Meters and Controls, Ltd., and is chairman of the British Industrial Measuring and Control Apparatus Manufacturers' Association.

MR. H. C. HARRISON, chief executive (engineering) of Flight Refuelling, Ltd., Tarrant Rushton, Blandford, Dorset, has been appointed a director of the company.

The Brightside Foundry and Engineering Co. Ltd., announce that MR. A. H. BRINKMAN, formerly manager of the Portsmouth branch of the company's Heating and Air Treatment Division, has now been appointed branch manager at Liverpool; and MR. P. BAVERSTOCK has become branch manager at Portsmouth.

MR. JOHN MACNISH, C.A., of Charterhouse Industrial Development Co., Ltd., has been appointed a director of the Aluminium Castings Co., Ltd., to fill the vacancy caused by the death of MR. R. S. DYBALL.

MR. M. E. O'KEEFFE TROWBRIDGE, B.Sc., A.C.G.I., A.M.I.Chem.E., has recently joined the head office staff of Sharples Centrifuges Ltd., Stroud. Formerly he was head of the Projects Initiation Department of Head Wrightson Processes Ltd., London.

MR. H. WILLIAMS, M.B.E., T.D., A.M.I.E.E., has been appointed manager of the Worcester branch of British Insulated Callender's Cables Ltd., in succession to the late MR. C. H. PANTING.

The Cape Asbestos Co. Ltd., London and South Africa, announce the following appointments: MR. A. G. GRANT as commercial manager (home), and MR. M. H. REID as commercial manager (planning and overseas); MR. M. A. F. NEWTON as personal assistant to the sales director, MR. K. C. GRAY. MR. H. BARTY-KING has succeeded Mr. Newton as publicity manager, and MR. N. A. C. JAMES has become southern area sales manager in place of Mr. Grant.

MR. PETER E. M. SHARP, B.Sc., A.M.I.E.E., has left the Telegraph Construction and Maintenance Co., Ltd., to join the China Engineers Ltd., the company's agents in the Far East. He will be stationed for the time being at Kuala Lumpur, Malaya.

Lloyd's Register of Shipping announce that MR. W. BENNETT, O.B.E., B.Sc., principal surveyor for the United States, will retire on December 31. He will be succeeded by MR. W. J. ROBERTS, B.Eng. MR. C. MACPHERSON, B.Sc., is to be principal engineer surveyor at New York from January 1, 1954, and MR. J. O'CONNOR has been appointed secretary to the American Committee from January 1, 1954.

MR. L. H. COOPER, chairman of the Mond Nickel Co., Ltd., has been elected a vice-president of the parent company, the International Nickel Company of Canada, Ltd., as from January 1, 1954.

GLYNWED TUBES LTD., Bilston, Staffordshire, have acquired the share capital of Hipkiss Brothers Ltd., Blackheath, Staffordshire, and of their subsidiary company, STEELWAY LTD., Wolverhampton.

From December 1, Evershed and Vignoles, Ltd., have taken over the distribution of products manufactured and previously marketed by Tinsley (Industrial Instruments) Ltd. In future, all correspondence on Tinsley instruments should be addressed to Evershed and Vignoles, Ltd., Acton-lane Works, Chiswick London, W.4. (Telephone, ELGar 6081). Evershed and Vignoles Ltd. also announce that MR. W. A. SHAW, A.I.E.E., has been elected to the board and appointed sales director. MR. H. W. GRIFFITHS, A.M.I.E.E., succeeds Mr. Shaw as general sales manager.

EXHIBITS AT THE SMITHFIELD AGRICULTURAL MACHINERY EXHIBITION.

(*For Description, see Page* 790.)

FIG. 6. DIESEL TRACTOR.

FIG. 7. DAVID BROWN-BENTALL DISC HARROW.

FIG. 8. BOUGHTON HD2 HEAVY-DUTY WINCH.

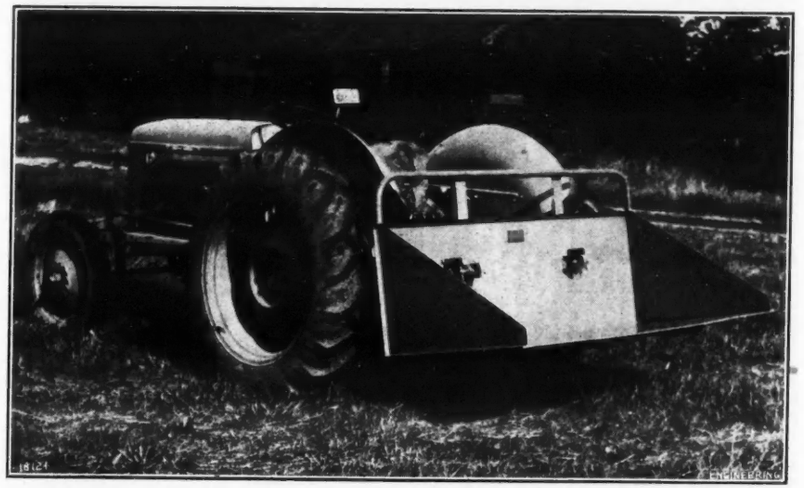


FIG. 9. TRACTOR TRANSPORT BOX.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

Registered at the General Post Office as a Newspaper.

We desire to call the attention of our readers to the fact that the above is the address of our Registered Offices, and that no connection exists between this Journal and any other publication bearing a similar title.

Telegraphic Address:
ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:
TEMPLE BAR 3663 and 3664.

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SUBSCRIPTIONS.

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For Canada	£5 5 0

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ADVERTISEMENT RATES.

Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

INDEX TO VOL. 175.

The Index to Vol. 175 of ENGINEERING (January-June, 1953) is now ready and will be sent to any reader, without charge and postage paid, on application being made to the Publisher. In order to reduce the consumption of paper, copies of the Index are being distributed only in response to such applications.

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ENGINEERING

FRIDAY, DECEMBER 18, 1953.

VOL. 176. No. 4586.

MONEY FOR ROADS.

THE announcement by the Minister of Transport last week that there is to be a substantial increase in the national expenditure on roads is indicative of a change in the pattern of work on which the men and women of this country are engaged. A gradual switch of resources to capital works of construction is now apparent. The worst post-war shortages of consumer goods having been eradicated, it is possible to attend to those basic needs of an industrial community which govern productivity and prosperity. Roads are of primary importance, but they have been sadly neglected.

The Minister said that from the Road Fund—to which road users contribute nearly 400,000,000*l.* annually—it is proposed to draw a sum that will increase from 5,000,000*l.* a year to about 15,000,000*l.* by the year 1957-58. He added that it was the intention that expenditure should then continue at that level for a period of years. In all, the Government were committed to authorise in the next three years schemes that would ultimately cost about 50,000,000*l.* The least satisfying part of his statement was, perhaps, the phrase "and shall continue at that level for some years." True, the proposed expenditure will be about three times that of recent years, but a more hopeful suggestion of even greater expenditure in years to come would have been welcome. The immediate expenditure proposed—assuming that it is spent—is good news so far as it goes. It is now fifteen years since any major road construction was undertaken, and road-making practice is virtually in the same state as it was in 1939, when mechanical methods of road-laying were first being introduced. It will take some time to apply to road construction the many lessons learnt when building runways for airfields and to put into practice the knowledge acquired so assiduously at the Road Research Laboratory. Many of the required schemes are concerned with the broader field of civil engineering and involve the construction of new bridges and tunnels.

In the course of his statement, the Minister indicated a number of schemes which it was intended should be undertaken forthwith. Perhaps the largest single item to be authorised in the coming year is the Whiteinch-Linthouse tunnel for Glasgow, the estimated cost of which is expected to be 3,000,000*l.* Much preparatory work has still to be done for this project before actual construction can be commenced. Of a similar character is the completion of the Dartford-Purfleet tunnel, under the River Thames, on which 850,000*l.* has already been spent in driving the pilot tunnel and other works, and on which maintenance charges are running at 10,000*l.* per annum. Originally, the project was expected to cost 3,500,000*l.*; according to the Minister's statement, however, the Government will be committed in 1955 to a sum of nearly three times this figure to complete the work. Its completion will mean a considerable saving in traffic operating between Kent and Essex and is expected to ease the traffic congestion in the City of London. This congestion is caused, in part, by vehicles which now make the 40-mile detour to avoid the bottlenecks of the Rotherhithe and Blackwall tunnels and the inadequate provisions of the Tilbury and Woolwich ferries.

Similar projects of major developments in trunk communications which were mentioned in the statement, but which were described as being beyond the country's resources, included the new Severn bridge, for which plans are now virtually complete, and the new Forth Bridge. In respect of the latter, however, the Minister indicated that if Sir Bruce White's plan for embodying a road bridge within the structure of the existing railway bridge proved impracticable, or some other preferable alternative could not be proposed, he would authorise the British Transport Commission to proceed immediately with improvements to the present ferry service. Unmentioned altogether was the suggested road link, either by tunnel or by bridge, into Hull from the south.

Of the trunk-road schemes that are to be authorised in the coming year, two at least are aimed at improving the communications between the centre of London and the airports: the Cromwell-road extension (of which the final alignment is not yet settled) and the duplication of carriage-ways along Western-avenue, the A40 road in Middlesex. Including Western-avenue, six of the ten major schemes proposed are road-construction schemes in which the construction of the road pavement, together with the sub-grade and drainage, are the principal engineering problems to be overcome. The Cromwell-road extension does not come in this category, as it will involve a considerable amount of demolition of existing buildings and reconstruction within a highly-urbanised area.

In addition to the large schemes that were mentioned specifically by name, the Minister indicated that a "substantial number" of smaller schemes were to be undertaken, amounting in the first three years to several million pounds. These have been selected as being "black spots" where a comparatively small expenditure in each case is likely to bring a large dividend in road safety, or where schemes have already been started and where considerable capital sums are at present lying idle. There are also various schemes for classified roads, to be sponsored by local highway authorities with some financial assistance from the Ministry of Transport.

Many organisations have given consideration to the needs of the roads and have put foward schemes of their own. Among the more responsible of these organisations is the Transport Users' Policy Committee of the Federation of British Industries, whose report on road expenditure was recently adopted by the Grand Council of the Federation. After summarising the various losses endured by industry and the community at large due to the shortcomings of the existing road system, the report lists the work which requires to be done, and continues by making proposals whereby the necessary capital might be raised to finance their execution. The principal classes of work which the report lists include the building of a limited number of motorways—about 800 miles—to link the main industrial and distributive areas and the improvement of alignment of existing trunk roads, particularly the provision of dual carriageways. These are followed, in the report, by improvements to road communications within cities and towns, including orbital roads; the completion of major projects such as the Dartford-Purfleet tunnel and the construction of the Severn Bridge; and the general elimination of "black spots" which create delays, congestion and accidents.

The three proposed means for paying for the new work that are given in the Federation's report are in no way original but they are worth restating. The first is a loan raised by the Government and serviced specifically out of motor taxation; the second is financing the schemes out of revenue, as at present; and, finally, building and financing major projects, such as the London to Birmingham motorway and the North-South Lancashire motorway, as toll roads. The advantages of the last-mentioned method are that the cost falls fairly and proportionately on the actual user and that there is a continuous return against money expended, whether from revenue or as the result of a loan. In this country the example of the Mersey Tunnel shows that road users are willing to pay on each occasion for the privilege of using a route which is markedly superior to others. In the United States and elsewhere experience proves that toll roads are acceptable. Industrial firms clearly stand to save transport costs in this way, though they would be justified in suggesting that the money for construction should come from the Road Fund to which they contribute so heavily.

The benefit of the works to be authorised by the Government will be small in relation to the improvements which could be effected if more money could be allotted to roads. It has been estimated that it would cost about 1,500*l.* million to raise the standard sufficiently to match present-day traffic, but there are other industries and services—notably the railways—which have for too long been restricted in capital expenditure. A suggestion which has been made that the railways might be scrapped, the tracks removed and magnificent new roads laid in their place, is not likely to be taken seriously, though it is likely to be carried out where secondary railway lines are being closed down. The railways carry vast quantities of coal and other bulk traffics which lorries could not handle, though the proposed Grand Contour Canal, which Mr. J. F. Pownall described in last week's issue of ENGINEERING, might take over some of it. The same contention—that roads could be the means of transport that railways are—has led some commentators to regret the fact that the steam engine preceded the internal-combustion engine. Undoubtedly the enormous capital sums which have been spent on railways, if they had been applied to roads and motor vehicles, would have given this country a road-transport system beyond imagining to-day. But it is an idle speculation. Britain has both roads and railways, and both are in need of extensive modernisation.

LEGISLATION AND COST OF ELECTRICITY METERING.

KELVIN once said that no real progress could be made in any science until accurate and convenient means were available to ascertain, measure and record the various phenomena associated with it. There are, however, more mundane reasons why such means should exist, reasons not unconnected with the naturally antagonistic relationship between buyer and seller. Weights and Measures Acts, some of considerable antiquity, have been promulgated, therefore, the purpose of which is to fulfil three main functions, namely, to establish a uniform system of units throughout the country and thereby to provide a common language of quantity between the parties to a transaction; to provide some system of control of the weighing and measuring instruments used, so as to ensure that they are maintained in accurate condition and thus to prevent fraud; and to afford adequate protection to the public against shortage. The implications of these measures are obviously both wide and fundamental and apply, *inter alia*, to the sale of electric power. This last is a form of trading which is also covered by the Electric Light (Clauses) Act, 1899, and the Electricity Supply (Meters) Act, 1936; measures which provide for the approval of various types of meters and specify the apparatus to be used in testing them.

Section 49 of the Electric Lighting (Clauses) Act lays down that the amount of energy supplied by an electricity undertaking to a consumer is to be ascertained, unless otherwise agreed, by a duly certified meter. It was not until some years later, however, when an ingenious gentleman in East Ham refused to pay his bill on the grounds that his meter was inaccurate, that it was found that no machinery existed for implementing this section. In the event, it was held by the courts that the complaints contention was justified and the Electricity Supply, (Meters) act was passed to regularise the position. This measure provides for the appointment of meter examiners, and the installation of suitable apparatus for testing the meters. That this was necessary is indicated by the fact that a preliminary survey showed that one-sixth of the total of the then electricity supply undertakings had no testing facilities, while the apparatus possessed by the other undertakings could only be described as crude.

The certification of meters in accordance with the Meters Act began in 1938 and should have been completed within ten years from that date. Owing to the war, however, the Act was suspended by a Defence Regulation in 1943, while in 1949 the decade was extended by two years. In the meantime, standards of apparatus and testing had been drawn up in consultation with the National Physical Laboratory, the supply undertakings and the meter and instrument manufacturers and a good deal of money had been spent on the necessary equipment of the testing stations. As pointed out by Mr. S. Howarth during a discussion on "The Influence of Legislation on the Costs of Metering," which took place at a meeting of the Measurements Section of the Institution of Electrical Engineers on Tuesday, December 1, legislation has increased the cost of metering in varying degrees, depending on the previous arrangements. On the other hand, it has resulted in an improvement of both standards and conditions; and has fulfilled the intention of the law by giving reasonable protection to the consumer.

As we have said, however, these changes have not been effected without some cost, and means whereby this cost could be reduced have been given close examination. For instance, the design of the meter itself has received attention; and the price of certification and incidentally of collection of the consumers' contribution have been investigated. As regards these points, a number of speakers in the discussion thought that money might be saved by co-ordinating testing and certification, although we are not quite certain what is implied in this dual procedure. Less accurate meters were also suggested as a remedy, a change which would mean the abrogation of the present legal limits of error, which lay down that a meter must be accurate within 2½ per cent. fast and 3½ per cent. slow on any load at which it may be operating. It was argued that there was no need for such accuracy in the 16 million domestic meters now in use or to have dials capable of being read to one-tenth of a kilowatt-hour when that unit only cost about a penny.

It was even suggested that electricity consumed on domestic premises might be charged for like water, a meter of low accuracy being installed only to indicate excessive consumption. It is interesting to speculate what the shades of Arthur Wright and other protagonists of the scientific tariff would have thought of this idea; and we look forward to a further discussion, to take place early in the New Year, when this matter will, doubtless, be fully ventilated. It is only right to add that, on the occasion to which we are referring, most speakers favoured accuracy; and pointed out that the cases of water and electricity were not analogous, since electricity was invisible. It was noted, however, that, even with the present limits, a discrepancy of 6 per cent. was possible between the charges for identical consumption, details being given of tests showing that the accuracy of a meter depended on its loading and times of working. For instance, in an area where most meters were running light the net performance was slow. On the other hand, it appeared that, taking a broader view, not a great deal was wrong, since, despite individual inaccuracies at various loadings, the integrated effects over a quarter give a bill well within the specified limits. In fact, this long-term view might provide a practical way of interpreting accuracy, too great an insistence on which is likely to affect manufacturing costs and thus introduce further complications.

The fact that meter inaccuracy may lead to loss of revenue postulates the periodic overhaul and re-testing of these instruments. The cost of these operations falls to be borne by the supply industry, the fee charged for certification only providing a partial set-off. It is true that some saving under this heading has already been achieved by adopting a sampling procedure and, as more experience is gained, this should be allowed to become more general. Other costs have arisen from the need for more care and attention during tests to ensure the higher stability and quality envisaged, as well as for adjustments that are made to meters while on circuit and the replacement of those which cannot be certified. Another change will arise if the suggestion that the period of validity of certification should be limited to, say, 15 years, as this would necessitate from one to one and a half million meters being dealt with annually. This is, perhaps, not a very considerable proportion of the total, but as the use of electricity becomes more general the aggregate figure is likely to rise and the work involved increase correspondingly.

The present position with regard to metering, therefore, offers a major problem in both engineering and economics, the solution of which is to arrange matters so that any loss in revenue due to the inaccuracy of the instruments is in proper balance with the additional cost of maintaining a superior accuracy. To do this will not be without its difficulties, since it will demand a careful measurement of consumption at various loads and almost certainly a translation of the results into financial terms, with due regard to the fact that meters do not always err on the low side.

NOTES.

RAILWAYMEN AND THE PUBLIC.

An old and oft-debated question is at the root of the clash between the National Union of Railwaymen and the British Transport Commission: are railways to-day inevitably a burden on the State, due to external factors over which the railways have little or no control, or can they pay their way? The Commission's accounts for 1952 showed a revenue surplus of 8,400,000*l.*, but any hopes that this feature would be continued have since faded. Some time ago the Government intervened, on behalf of the travelling public, in a question of railway fares being raised to cover increased costs, and now that the railwaymen claim that they have a legitimate grievance because their wages are low in relation to those in other industries, all hope of the railways making a profit can be abandoned. Unfortunately the major parties on each side in the dispute—the N.U.R., the Commission, the Ministry of Labour, the Ministry of Transport and the Government—not unnaturally, suspect the other side of being biassed. In these circumstances a satisfactory settlement is not readily reached. If the railwaymen's claim is to be met, at least in part, if the loss on railways is to be minimised, and if fares and rates cannot be increased, there are only two solutions: that the total railway staff should be reduced, and that "productivity" on the railways should go up. Both are worthy of examination.

GOVERNMENT SERVICES FOR EXPORTERS.

As is probably appreciated to a greater or lesser degree by readers of ENGINEERING, the Board of Trade has a general responsibility for the industry and commerce of the United Kingdom. It is probably equally true to say that the full extent of its activities is not so well known; in fact, the Select Committee on Estimates recently recommended that further steps should be taken to publicise its services. This recommendation has now been implemented by a letter, which the Minister of State at the Board of Trade (Mr. D. Heathcoat Amory) has sent to 50,000 individual manufacturers and trade associations. This letter points out the need for increasing our exports, as well as the necessity for making sure that no firm which could export, or could export more, is failing to do so. It is accompanied by a leaflet setting out what the Government offer to that end and by a postcard which will enable the firms approached to be placed in one of five categories. As a result of the perusal of these documents, those to whom they have been sent will learn that the Government are in a position to give advice about the areas in which particular goods are most likely to find a market, as well as about local marketing methods, climatic requirements, economic conditions and other special factors. In addition, assistance can be given in the appointment of local agents and information can be provided about local ways of doing business, the circumstances of overseas firms, tariff rates, official requirements and regulations, and goods required. Further, help for the traveller and the exhibitor and insurance against risks are available. The objects underlying this campaign are not only worthy, but necessary at the present time; and we hope that it will receive the support of those for whose benefit it has been instituted.

PERKINS DIESEL ENGINES IN INDIA.

Mr. Frank Perkins, chairman and managing director of F. Perkins, Limited, Peterborough, speaking at a cocktail party given by his firm at the May Fair Hotel, London, W.1, on Friday, December 4, said that the current year was a momentous one in the history of the company. In it, they had celebrated the 21st year of their existence and had also attained what he believed was a record production of high-speed Diesel engines for any manufacturing unit in the world. Last year the output of the engines produced amounted to 2,550,000 h.p. Perkins engines are distributed in India by Simpson and Company, Limited, of Madras, who have, comparatively recently, set up an assembly plant for producing the engines from components manufactured at Peterborough. Now, some of the components are being made in India and it is intended that the proportion so produced shall be increased as far as possible. Mr. Perkins is now visiting India and one of the objects of his visit is to see how the local production of engine components can best be increased. Spare parts and service facilities for the engines exist throughout India, and another reason for Mr. Perkins's visit is to see whether this service is capable of improvement. Perkins engines are made with three, four or six cylinders in types suitable for use on road vehicles and tractors; other types are made for industrial purposes and for marine propulsion. In most cases the cylinder bore is 3½ in. and the piston stroke 5 in.

AIR POLLUTION AND THE LAW.

At a joint meeting in Liverpool of the North Western Section of the Institute of Fuel and of the North Western Division of the National Smoke Abatement Society, on Thursday, December 3, Mr. A. Marsh said that the present law in Britain relating to the abatement of smoke dated back, in its essentials, to 1875. It was time it was modernised, as it was concerned only with the action to be taken after smoke had been emitted. What was wanted was a better definition of the limits of allowable pollution; prior approval of all new fuel-burning installations, except those for domestic use; powers for local authorities to plan smokeless zones without the expense and trouble of a private Act; and powers to ensure that when better legislation was available it should be operated effectively. The last point was important. Although many local authorities had made excellent use of the powers they possessed, others had not and many had not even sought to obtain such by-law powers as were available. Moreover, a few that had sought powers since the war had had considerable difficulty in obtaining ministerial approval. There were also insufficient qualified smoke inspectors. Many more were needed and should be given a higher status. The other great country suffering seriously from air pollution was the United States. In some respects, especially in the measurement of air pollution, this country was ahead of them, but as far as legislation was concerned they were in advance of us. In this connection, however, it was significant that even the National Smoke Abatement Society, in the present state of public opinion, did not consider it advisable to advocate legislation going so far as that being applied successfully in many American cities.

LETTERS TO THE EDITOR.

EXTINGUISHING OIL FIRES BY FOG NOZZLES.

TO THE EDITOR OF ENGINEERING.

SIR,—The concluding sentence of the article on extinguishing oil fires (page 671 of your issue of November 20) reads "This method of fire fighting has now been standardised for the Swedish Navy and merchant marine." This statement is ambiguous and perhaps I am not the only reader who would like to see it clarified.

The provisions of the International Conference on Safety of Life at Sea, 1948 (H.M. Stationery Office, Cmd. 7492) were adopted by the signatory countries on November 11, 1952. *Inter alia*, these regulations call for:—

Machinery Spaces.—Fire hydrants with nozzles suitable for spraying water.

Oil-Fired Boiler Rooms.—The provision of froth or alternatively of smothering gas or a fixed high-pressure water-spraying system.

Many spraying devices on the market meet the requirement for the machinery spaces; the volume of burning oil involved is small and the spray is required primarily for cooling, not for extinguishing. Matters are different in oil-fired boiler rooms, where fires of oil in big volume can develop from various causes. For this exacting requirement the Board of Trade have so far approved only water-spraying systems that produce a non-burning emulsion of the oil-in-water type. It is for this reason that I venture to ask for a more specific expression of the claim entered.

Yours faithfully,
S. F. BARCLAY.

Ashdene,
Sherwood Avenue,
Sale, Cheshire.
December 9, 1953.

TITANIUM—A METAL OF ENGINEERING IMPORTANCE?

TO THE EDITOR OF ENGINEERING.

SIR,—I am most grateful to Mr. George Wansbrough for his letter on my British Association Lecture, (page 756, *ante*). He has, I am glad to say, drawn attention to two slips hitherto, as far as I know, undetected by my audience or by subsequent readers.

The errors of significance are not, however, in Table VIII, but in Table VII. Here, the cost per lb. of disposable load should be, for the Super Constellation, 8·8*l.*, while that of the Convair 340 should be 16·1*l.* and not 8·5*l.*

Yours faithfully,
P. L. TEED,
Major.

Vickers-Armstrongs Limited,
Weybridge Works,
Weybridge,
Surrey.
November 30, 1953.

TUBULAR TOWER FOR TRANSMISSION LINES.

TO THE EDITOR OF ENGINEERING.

SIR,—The reader of the article on page 678 of your issue of November 27 would assume that the problems connected with the design, manufacture and galvanising of tubular transmission towers, which have, in the past few years, confronted the leading tower experts both in this country and abroad, have now been solved. Should this be so, then the authors are to be congratulated. They are correct in saying that considerable interest will attach to their work, and particularly because of repercussions on an export market which has become intensely competitive.

From this aspect it seems a pity that Tubewrights, Limited, should have felt it necessary to conduct their tests in Italy, when a first-class British tower-testing plant is available, thus giving to the Italian S.A.E. Company, keen competitors of British firms in this field, the opportunity of witnessing the successful tests. At the same time it would appear that similar facilities were not extended, as is usual on these occasions, to expert personnel from either the British Electricity Authority or consulting engineers, or to representatives of the British technical Press. In the absence of impartial witnesses, therefore, it is of paramount importance that a subsequent article written should be presented with the utmost clarity and be incapable of misinterpretation.

The writer, having been associated with all major developments in the design of high-voltage transmission-line structures in this country for the last fifteen years, and who has, furthermore, been personally connected with several of the events referred to in the article, would like certain aspects to be made clear and asks for the favour of a reply to the following comments.

(1) The writer concedes that previous efforts to produce a high-voltage transmission-line tower of tubular construction have not been successful. The reasons given by Messrs. Tubewrights are only subsidiary to solving the major problem, that is, hot-dip galvanising the tubes after fabrication. The object was to galvanise the tubes both internally and externally and so guarantee complete protection. Tubewrights, Limited, state that completely sealing up the ends of the tube enables each member to be hot-dip galvanised. One would assume, therefore, that this operation would have been proved on the prototype, but this is not stated in the article, neither do the pictures give the impression of a

galvanised structure. The writer understands that although it may be possible on a hand-made prototype, it is quite impossible to guarantee complete sealing in mass-production conditions. In any case, the hot-dip galvanising of sealed tubes has been the subject of careful investigation, and the writer quotes an extract from a recent statement by the Industrial Safety Division, Information Bureau, of the Royal Society for the Prevention of Accidents :—

"We have now made further inquiries concerning this matter and we understand that the danger of this operation arises from the possibility of acid seeping into the tube during pickling. When this is raised to the bath temperature a very high pressure indeed may be developed. Some years ago the accidental dipping of a closed tube caused the zinc in the bath to be spread over the entire shop, resulting in the death of three operators and injury to others. It is therefore recommended that under no circumstances should closed tubes be galvanised. The practice is to leave one end open, and where the whole tube has to be dipped it is usual to attach an extension to the open end, thereby allowing any trapped gases to escape. We trust that the foregoing information will assist you to institute a safe system of work for this operation."

In view of this, will the authors state whether or not any of the sealed tubular members have been hot-dip galvanised ?

(2) The present transmission tower used by the British Electricity Authority for their 275/400-kV double-circuit lines, composed of mild and high-tensile steel angle sections, weighs 11 tons and is, presumably, the tower referred to in the article for comparison with the tubular tower. The tower now in use was successfully tested to the following conditions :

(*a*) Normal loading conditions (all wires intact)	Including factor of safety 2·5
(*b*) Earth wire broken (*c*) Top conductor broken (*d*) Middle conductor broken (*e*) Bottom conductor broken	Including factor of safety 1·5.

In describing the tests on the tubular tower the article does not state categorically that all the above tests were successfully carried out. Certainly a reference is made to a typical broken-wire condition, but this could, of course, be a broken earth-wire, which is a concentric load applied to the top of the tower and could not be expected to cause failure in the tubular bracings and, in fact, not even leg members, except in the top part of the tower. The broken-conductor condition with a longitudinal test load applied at the cross-arm end of 11·25 tons, as compared with the earth-wire pull of 5·4 tons, is of course by far the most important test condition on the tower. If the failure which the article describes as having taken place at 1·55 times the designed broken-wire load was, in fact, the load from the broken top conductor, then it is a most commendable result. Perhaps you would be good enough to have this point clarified.

(3) While the successful designing and testing of a tubular tower is a technical achievement of some merit, it is of little commercial value unless it can be supplied and erected at a lower cost than its predecessors. The writer's experience is that the successful solution of all the problems connected with galvanised tubular structures results in their being more costly than orthodox construction using open sections.

The writer has the privilege of being the official British representative on the Towers and Foundations Committee of the Conference Internationale des Grands Reseaux Electriques (C.I.G.R.E.), and is also on a similar committee for the Electrical Research Association, and can state that this question of tubular construction is one of topical interest to transmission-line experts all over the world. Many questions are going to be asked about Messrs. Tubewrights' latest achievement, and from a British national viewpoint it is desirable that accurate information should be available.

Yours faithfully,

A. E. PERCIVALL.

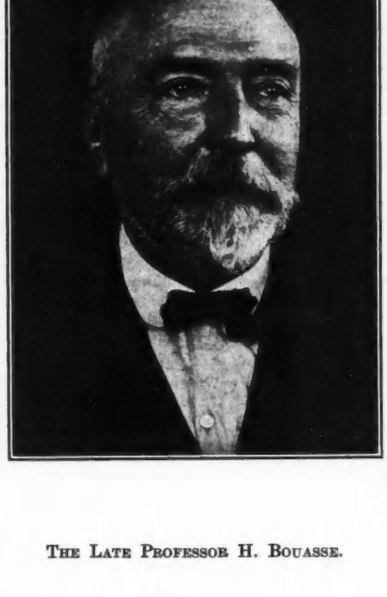
90-94, Brompton-road,
London, S.W.3.
December 2, 1953.

OBITUARY.

PROFESSOR HENRI BOUASSE.

ENGINEERS and physicists throughout the world who knew Professor Henri Bouasse, directly through his personal teaching or indirectly through his voluminous writings, will learn with regret the news of his death, on November 15, which we have just received from Toulouse.

Henri Pierre Maxime Bouasse was born on November 16, 1866, in Paris, of a family who had been printers and publishers there for a century and a half. His early years, spent in daily contact with an important industry, developed in him an insight into technological processes which was to be one of the outstanding features of his subsequent work. The varied nature of his early education, partly under religious auspices at Saint Croix



THE LATE PROFESSOR H. BOUASSE.

(Neuilly), and Saint Elme (Arcachon), and partly at the École Bossuet, contributed much to the versatility of his outlook. In 1883, he entered the Lycée Louis-le-Grand and, in addition to classes there, attended courses in physics and law at the Sorbonne. Two years later, he qualified in the open competition for admission to the École Normale Supérieure where, within three years, he graduated as Licencié and Agregé in physics. The years 1888 to 1891 were passed under the direction of Mascart, to whom Bouasse acted as *préparateur* at the Collège de France, and who insisted that he should spend a couple of years laying a solid foundation of general experimental technique, and studying portions of the fundamental original literature of his subject, before working for his doctorate.

In 1891, Bouasse was appointed to his first post, at the Lycée at Agen. In October, 1892, he was transferred to Toulon and, a month later, joined the staff of the physics department at the University of Toulouse. In the following December, he took his doctorate in mathematics and then turned to an experimental investigation of photographic action. The next subject to claim his attention, and to hold it for ten years, was the deformation of metal wires under stress. Mascart, well aware that the secret of spectacular success in research lies in "getting in on the ground floor" when a boom begins, warned his erstwhile *préparateur* that concentration upon a subject of such complexity was unlikely to yield any tangible reward and that it would pay him better to follow the prevailing fashion and study Hertzian waves ; but Bouasse, whose aim from the outset was to advance science and not himself, was not to be deflected from his purpose. Certain preliminary results of these experimental studies in elasticity were embodied in the thesis, "On the torsion of fine wires," for which the doctorate in physical science was conferred on him in 1897. Details of the subsequent progress of these carefully executed and precisely controlled investigations are reported in the *Annales* and *Journal de Physique*, and *Les Annales de la Faculté des Sciences de l'Université de Toulouse*, where they extend to some 600 pages. In the same year, Bouasse succeeded F. G. A. Berson as professor of physics at Toulouse and served in that capacity until his retirement in 1937, refusing an invitation, in 1906, to forsake the calm of the provinces to succeed Pierre Curie at the Sorbonne.

Bouasse was singularly devoid of the conventional academic vices. He was no pathetically unpractical figure, weighed down under a burden of learning, but a man of multiple interests, capable of appreciating life to the full. He inherited his father's literary tastes and, in one of his letters, wrote "I should be sorry to retire without devoting some time to non-scientific reading, to clear my mind of *x*'s and *y*'s. A professor is not a machine for fabricating memoirs, and his students are happy to find in him something besides a perambulating text-book." Bouasse's own students enjoyed the privilege of contact with a mind mellowed with wisdom rather than sodden with learning, and a learning, and the stimulus of intercourse with a personality whose breadth of culture was the fruit of a wide general reading projected against the background of a concrete vision of men and things. The latter was largely acquired through extensive travel, his chief form of relaxation. In 1888, he visited Constantinople by way of Austria, Hungary and the Balkans. In 1891, he spent three months in the Near East, mainly in Syria and Palestine. His first acquaintance with the Sahara went back to his time at Agen, and it so fascinated him that he revisited it a score of times. His most distant voyage was to India and Ceylon, but he also travelled in Egypt, journeyed down the Niger and wandered through nearly all the countries of Southern Europe.

Bouasse's teaching had a high inspirational quality and the two lectures that he gave each week throughout the session were models of their kind. They exemplified his contention that "science can only be educative if sufficiently exhaustively studied, while to acquire a smattering of everything is to risk systematic stultification and encourage the callow pose of omniscience. The utilitarian approach to science need be neither sordid nor superficial, and does not exclude its cultural aspects." In addition, Bouasse held one *conférence* a week, during which a member of his class was interrogated in front of the class on some problem arising out of the lectures, and was made to set up apparatus to illustrate it experimentally—a somewhat nerve-wracking ordeal.

It was towards 1900 that the project of writing a treatise on physics first took shape in Bouasse's mind, and to its realisation he devoted practically his whole time for the next 32 years. Throughout this period he would reach the University at about 5.30 a.m. in summer and 6.30 a.m. in winter, and would work until 6.0 and 7.0 p.m. with only a short break at mid-day. The first edition of his *Cours de Physique*, in six volumes and just over 2,000 pages, was published between 1907 and 1909. In it, Bouasse's exceptional command of his subject and unrivalled power of presenting it were already patent, and so popular did it prove as a University text that the edition was rapidly exhausted. The slim first volume on "Physical Mechanics" was then expanded sixfold and divided into two volumes, which appeared in 1910 and 1912. For the definitive edition of his great enterprise, Bouasse selected the title *Bibliothèque Scientifique de l'Ingenieur et du Physicien* and adopted for it the motto "Beaucoup de Science mais en vue des applications," which

appeared on the title page of every volume. Published by the Librairie Delagrave, Paris, it consisted of 45 octavo volumes, containing 20,000 pages of text, some 900 pages of preface and nearly 600 pages of index. It constitutes the most important and comprehensive collective work on physics ever written, or likely to be written, by a single author.

The magnitude of the undertaking was even more formidable than might at first be imagined, since none but original sources of information were consulted in its preparation, and most of the phenomena described were reproduced in Bouasse's own laboratory, either by himself or his assistants. To survey so vast a field and to assimilate its multilingual contents needs tremendous physical endurance and mental concentration; to analyse and appraise conflicting individual contributions demands a highly developed critical faculty; to extract the essential from each and place them in proper perspective calls for an unbiassed and constructive mind, while to synthesise this raw material in accordance with a carefully conceived plan and to present the final result concisely and lucidly necessitates uncommon powers of integration and mastery of style. A penetrating insight is usually needed to detect error, and to expose error whenever and wherever it is found often requires moral courage of a high order. All these qualities Bouasse possessed in a superlative degree. As he never sought advancement or indulged in the intrigues inseparable from university life, he was not exposed to the temptation to hedge, once he had reached his conclusions. He detested pomposity, prolixity and other intellectual aberrations, and abhorred vague and sweeping generalisations.

His own words will convey most clearly his point of view: "One of the reasons of my unpopularity in official circles is that I am content to set down in ordinary comprehensive language, devoid of eloquent phraseology, what passes for the profoundest of truths and to reason invariably on the most commonplace of examples reduced to their simplest terms. . . . The educative value of a science resides not in its conclusions, which may be controverted, but in the nature of the proofs whereby they are established. . . . To be educative, teaching must keep as close as possible to applications which serve to fix the concrete implications of laws. . . . To achieve clarity in the presentation of any particular topic the choice of the preliminary postulate is all important. Boltzmann on the kinetic theory is, I agree, a marvel, but it is decidedly difficult for the ordinary run of mortals to grasp. Instead of bothering to attempt demonstrations of its postulates on the basis of the theory of probability, is it not simpler to say 'we admit that the velocities of the moving particles are distributed in accordance with a law which it will suffice to enunciate in order that what follows may be capable of direct logical derivation.' When you proceed in this way, science becomes accessible to all persons of good will and sound intellect."

Like most persistently productive men, Bouasse never gave any impression of being either hurried or harassed, and he always had time to spare to entertain a colleague. He placed no reliance upon notes, files or card indexes, but carried his material in his head, finally committing it to paper only when it had fully crystallised out. He never used a typewriter or even a fountain pen, but the manuscripts he sent to his publishers were admirably neat and legible. The very numerous line diagrams which are a notable feature of all his volumes were drawn by himself. His pages were never encumbered with footnotes and references; such a parade of erudition too often indicates what the author has not bothered to read or even to check. To the objection that their absence might be detrimental to research workers, Bouasse replied that he felt he could more adequately assist that small percentage of his readers by offering them a rational and coherent exposition than by selling them a catalogue, and that, in any case, in a properly equipped library, journal references should be readily traced.

The first two volumes of the *Bibliotheque Scientifique* contain the mathematics used in the succeeding volumes, together with an extensive selection of examples designed to develop the necessary facility in applying them. The next six volumes provide a complete course in mechanics, and following them is a volume on the theory of elasticity and strength of materials, in which Bouasse's own early researches are summarised. The succeeding group of eight volumes is devoted to the study of fluids. In the preparation of the two volumes on vortex motion, Bouasse had the experimental collaboration of MM. Fouché and Marty, and much original work is contained in them. The two volumes on thermodynamics originally appeared in 1913, and Bouasse prepared a revised and expanded version of the first of these, which was published in 1932. The course in magnetism and electricity extends to three volumes, published in the early part of the first World War, the intended revision of which was prevented by the second war. The section on optics comprises six volumes, two on geometrical optics (an enlarged edition of the first of these was published in 1934), one on optical instruments, one entitled "Vision et reproduction des formes et des couleurs," based largely on Bouasse's youthful memories; and two on interference and diffraction, in collaboration with the Abbé Z. Carrière, a former student under Bouasse and, until recently, Professor of Physics at the Institut Catholique de Toulouse, who was responsible for the magnificent aerograph illustrations of fringe patterns which embellish both these volumes.

The two following sections of the work contain four volumes dealing with crystallography, the study of symmetry and the optics of crystalline media, and an equal number devoted to electro optics, including electrical oscillations, Hertzian waves, emission, propagation and reflection of light. The next main division consists of seven volumes on acoustics, very obviously a labour of love, as Bouasse was a keen amateur musician and a competent pianist, and had contributed a volume to the Scientia Collection on the physical basis of music, some 25 years earlier. In preparing these volumes, Bouasse profited immensely from the experimental collaboration of M. Fouché, who, after a Conservatoire training in music, took his doctorate under Bouasse and who possessed a quite exceptional analytical ear. Thanks to this happy association, a number of false statements concerning musical instruments, perpetuated by those who compile texts by copying the work of their predecessors, were corrected, and many new results were reported. The concluding section of this monumental work comprises a volume on theoretical and practical astronomy and another on mathematical geography.

Each of these volumes is preceded by a preface wherein Bouasse ventilates with complete and often devastating frankness his views on the history, method, philosophy and teaching of physics, the foibles of physicists, the idiosyncrasies of mathematicians and a wealth of other topics from titles and decorations to the system of Taylor. They exhibit his style of writing at its most brilliant, being humorous, ironic and satirical in turn, and incendiary on occasions. They compelled attention and exercised a marked influence even upon those who pretended to ignore them. Mistakes there must be in a work of such magnitude, but their number is small in relation to the whole, and Bouasse never hesitated to acknowledge any that were brought to his notice or that he discovered for himself. The last contribution he made to this work was a "Critique et réfutation des theories exposées dans son ouvrage *Tuyaux et Résonateurs*," published in 1948. Of his many other works, including the set of exellent elementary physics texts written in conjunction with Brizard, the witty and penetrating survey of French teaching methods in the privately printed *Bachot et Bachotage*, and numerous articles, contributed to a variety of technical and other journals, there is no need to write.

Having for upwards of 30 years confined himself mainly to what Confucius deemed the first duty of a teacher, "to keep old knowledge warm," Bouasse proceeded to obey the second injunction "and to get new." In 1932, he began a series of experimental investigations in hydrodynamics, the results of which were published between 1933 and 1939 in ten lengthy contributions to *Les Annales de Physique*, *Les Annales de la Faculté des Sciences de l'Université de Toulouse* and the *Publications Scientifiques et Techniques du Ministère de l'Air*, which reveal his customary skill in devising experiments, superb manipulative dexterity, and unrivalled power of interpretation. On his retirement in 1937, the University placed a laboratory at his disposal and in this Bouasse continued his researches on hydrodynamics and acoustics. He worked with the same unflagging zeal throughout the war years and, by 1949, had over 2,500 pages of manuscript, with about 1,000 diagrams, awaiting publication. The disorganisation in France during the immediate post-war years has so far prevented their publication, but it is to be hoped that a renewed effort will be made to publish them as a tribute to his memory. Though hard hit by the changed conditions, he never complained. Failing powers caused him to curtail his daily visits to his laboratory, and, early in 1951, ill health compelled him to abandon the scene where he had laboured for close upon 60 years.

Bouasse was probably one of the last representatives of the old type of professor who delighted in teaching and did not regard it as a tiresome interruption to research. He received little official recognition and sought none, but the influence exerted by his major achievement, the *Bibliothèque Scientifique de l'Ingenieur et du Physicien*, has been and will continue to be profound and enduring.

MR. T. E. H. HEYWOOD.

WE regret to record the death of Mr. T. E. H. Heywood, which occurred at Glasgow on Thursday, November 26. He was 76 years of age and had long been connected with the mechanical side of railway work, both in this country and abroad.

Thomas Edward Hett Heywood was born on November 29, 1877, and was educated at St. Mary's School, Cardiff. At the age of 16 he became a pupil of Mr. T. Hurry Riches, then locomotive superintendent of the Taff Vale Railway. Subsequently he gained a scholarship at the University College of South Wales and Monmouthshire, where he studied for three years. He won a Whitworth Exhibition in 1899. In 1900, he returned to the Taff Vale Railway as draughtsman in the locomotive drawing office, but three years later became locomotive and carriage superintendent of the Burma Railways Company.

In 1905, he returned again to the Taff Vale Railway as junior assistant locomotive superintendent. In 1912 he was appointed chief assistant locomotive superintendent, but left two years later to be locomotive, carriage and wagon superintendent of the Great North of Scotland Railway. After the grouping of the railways he continued with the London and North Eastern Railway, first as district mechanical engineer, Manchester, and then, in 1927, as mechanical engineer and running superintendent (North Scottish Area) at Cowlairs, Glasgow. He retired in 1942. Mr. Heywood was elected an associate member of the Institution of Civil Engineers in 1902 and was transferred to the class of member in 1923. He was also a member of the Institution of Mechanical Engineers.

MR. C. G. GREY.

WE have also learned with regret of the sudden death, on December 9, of Mr. C. G. Grey, probably the most provocative and certainly the most widely known figure in aeronautical journalism during the past 40 years. He was 78 years of age, having been born on November 13, 1875, in London. He received his general education in Dublin, but studied engineering at the Crystal Palace School of Engineering. His association with aeronautical journalism dates from 1908, when he was a member of the editorial staff of *The Autocar*. In 1919, in conjunction with Mr. William Aston, he founded and edited *The Aero*. In 1911, in partnership with Mr. E. V. Sassoon (later Sir Victor), he founded *The Aeroplane* and edited it until 1939. Thereafter he continued to contribute to *The Aeroplane* and was also air correspondent to a number of provincial and foreign newspapers. In 1916 he succeeded Mr. F. T. Jane as editor of *All the World's Aircraft*, retaining this position until 1941 when one of his typically frank comments was considered to be offensive to the United States, and he therefore resigned. C. G. Grey was the author of many aeronautical books. He was an honorary companion of the Royal Aeronautical Society, and a founder member and honorary life member of the Royal Aero Club.

EXHIBITS AT THE SMITHFIELD SHOW.

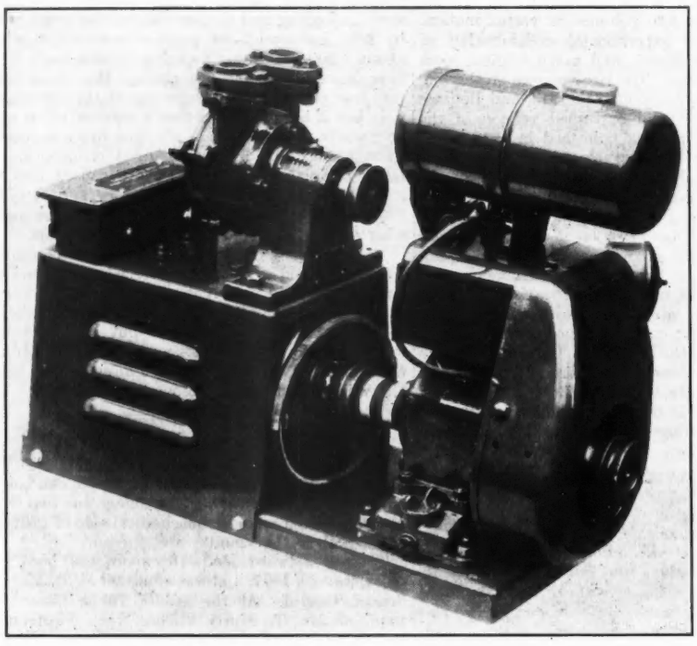


Fig. 10. Combined Alternator and Pumping Set.

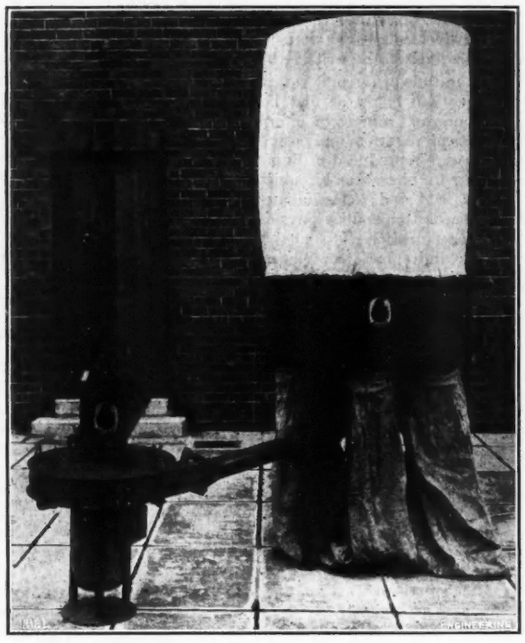


Fig. 11. Electric Hammer Mill and Bagging Attachment.

SMITHFIELD SHOW AND AGRICULTURAL MACHINERY EXHIBITION.

(*Continued from page* 746.)

Diesel Tractor.

Earlier this year, David Brown Tractors, Limited, Meltham, Yorkshire, introduced their 25VO tractor, a moderately light machine, fitted with a vaporising-oil engine. They have followed this up by introducing a Diesel version, which was shown for the first time at Earl's Court. Known as the David Brown 25D tractor, this machine is illustrated in Fig. 6, on page 784. With the exception of the engine and ancillary equipment, it is identical with the vaporising-oil model, the two engines being interchangeable in the same chassis. The Diesel engine is a four-cylinder unit fitted with overhead valves and having a bore and stroke of 3½ in. and 4 in., respectively. It develops 31·3 brake horsepower at 1,800 r.p.m. and is coupled to a three-speed twin-range gearbox which gives six forward speeds and two reverse speeds, thus conforming to the usual practice for David Brown tractors. The full range of 60 implements can be used with the 25D model, and although designed primarily for use with mounted equipment, it can be used with equal facility for trailed implements. By virtue of its compact design, it has good manœuvring characteristics, but it can, nevertheless, handle such machines as binders and pick-up balers. When in the lowest gear the speed is 1·46 m.p.h., but the maximum road speed in top gear is almost 15 m.p.h. It should prove practicable, therefore, to use the tractor for haulage work.

Adjustable Offset Disc Harrow.

The many implements displayed by David Brown Tractors, Limited, included at least two not exhibited before. One of these—the David Brown-Bentall adjustable offset disc harrow, is entirely new. This implement is manufactured by E. H. Bentall and Company, Limited, Maldon, Essex, and has been designed primarily for export. It is illustrated in Fig. 7, on page 784, and can be used with its two gangs trailing or mounted side by side as shown. When trailing, the working width is 4 ft. 6 in. and both gangs can be adjusted 1 ft. 6 in. to either the left-hand or right-hand side. The working width, when mounted side by side, is 8 ft. 6 in. and in both instances the angle setting can be varied by steps of 5 deg. between the limits of 10 deg. and 25 deg. The front and rear gangs are interchangeable so that when the harrow is offset to the right the rear gang can turn a right-handed furrow and, conversely, when the harrow is offset to the left the rear gang can turn a left-handed furrow, thus leaving no open furrows.

The main frame of the implement is fabricated from steel channel sections and each gang comprises eight discs. These are 22 in. in diameter and are spaced 9 in. apart on 1½-in. diameter high-carbon steel shafts. The bearing housings are of fabricated construction and are fitted with beechwood bearings.

Heavy-Duty Winch.

Another new implement not previously shown by David Brown Tractors, Limited, is the heavy-duty winch illustrated in Fig. 8, on page 784. This is manufactured by T. T. Boughton and Sons, Limited, Amersham Common, Buckinghamshire, and is suitable for use with David Brown tracked and wheeled tractors. The winch mechanism is totally enclosed and is operated from the power take-off of the tractor, the drive group consisting of a duplex roller chain and spiral-bevel gear assembly. Two levers only are needed to control the winch, namely, a brake lever situated to the left of the driver and a clutch lever to the right. The winch is of steel construction and is fitted with heavy-duty ball and roller bearings. The brake is exceptionally powerful and will hold any load within the capabilities of the tractor. The rope drum has a barrel diameter of 5¾ in., a flange diameter of 13½ in. and a barrel length of 14½ in. It will accommodate 100 yards of ½-in. diameter cable and 75 yards of ⅝-in. diameter cable. Two models are made, namely, the HD2 and the HD4, the former being fitted with a sprag and rollers as shown in the illustration, whereas the latter has neither rollers nor a sprag. Both models can be installed with equal facility on the David Brown Trackmaster "30" and "50" tractors, and the performance will vary, of course, not only according to which tractor is in use, but also to the speed of operation and the quantity of rope on the drum. With a bare drum and a power take-off speed of 467 r.p.m., the line pull on the Trackmaster "30," for example, is 17,400 lb. at 49 ft. per minute, and on the Trackmaster "50," 19,040 lb. at 64 ft. per minute. At the other end of the curve, that is, with a power take-off speed of 1,792 r.p.m., the line pulls are 4,500 lb. at 187 ft. per minute and 5,000 lb. at 244 ft. per minute for the Trackmaster "30" and "50," respectively, both pulls referring to a bare drum.

Tractor Transport Box.

Tractor-mounted transport, or carrier, boxes are gaining rapidly in popularity, particularly those designed for use in conjunction with rear-implement linkages as, in addition to giving a convenient means for transporting heavy loads, their use automatically increases the adhesive weight of the tractor and permits it to negotiate heavy land not normally within its capabilities when hauling a conventional trailer. A good example of such a carrier "box" is furnished by that illustrated in Fig. 9, on page 784, which was shown by the manufacturers, Whitlock Brothers, Limited, Great Yeldham, Essex. In the illustration, the "box" is shown installed on a Ferguson tractor, but it can be fitted to the hydraulic linkage of almost any tractor.

Combined Alternator and Pumping Set.

The exhibits on the stand of Arthur Lyon and Company (Engineers), Limited, 42-44, Telford Way, Acton, London, W.3, included a combined electric alternator and pumping set which was being shown for the first time. This unit, which is known as the Alco, is illustrated in Fig. 10. It has been designed to give enough power to light an average size farmhouse and pump water from a well to a roof tank, and is capable of carrying out these duties either separately or together.

The prime mover is a Villiers Mark 10, single-cylinder air-cooled petrol-paraffin engine which is connected directly through a flexible coupling to a self-exciting self-regulating single-phase alternator having a continuous output of 500 watts at 230 volts. An alternator is used in preference to a generator so that the unit can be used to operate standard wireless receiving sets and television sets. For this reason, a very accurate governor is fitted which controls the speed within fine limits to 3,000 r.p.m. Above the alternator is mounted a 1-in. self-priming centrifugal pump which has an output of 500 gallons per hour at the governed engine speed and a maximum suction lift of 27 ft. The pump is driven by a belt from a pulley mounted on an extension of the alternator shaft, the belt being removed and secured

EXHIBITS AT THE SMITHFIELD SHOW.

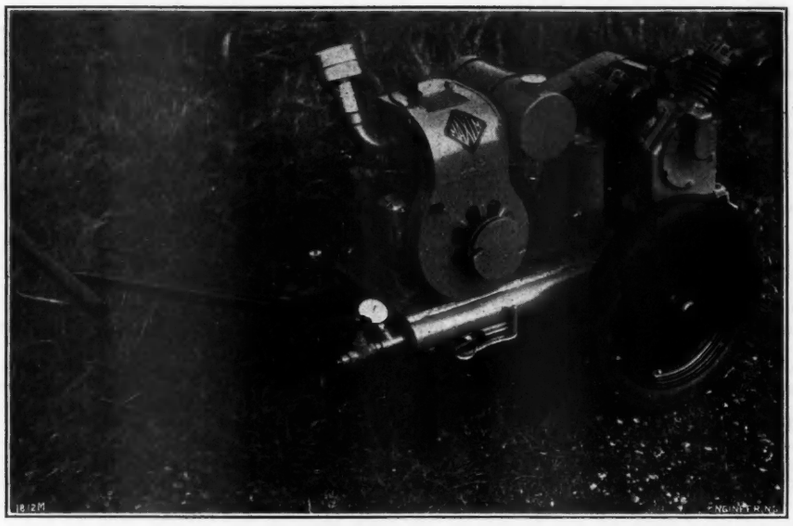


FIG. 12. PORTABLE AIR COMPRESSOR.

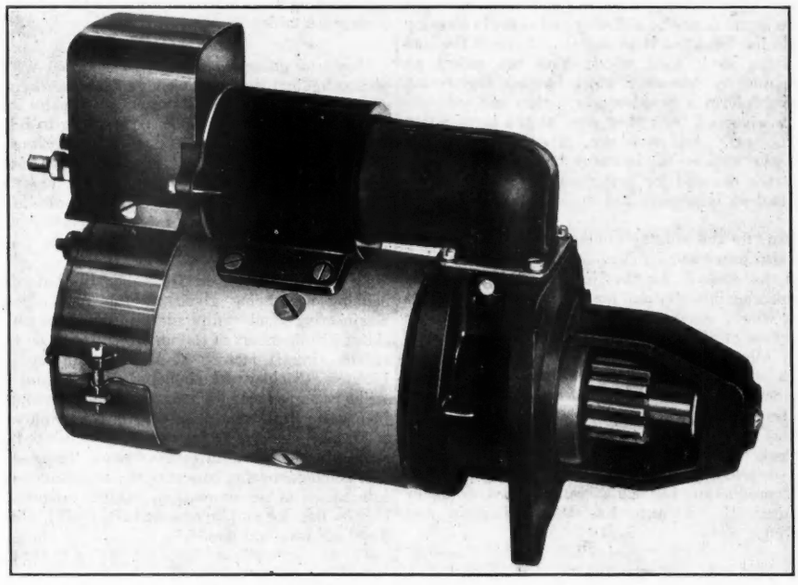


FIG. 13. STARTER MOTOR FOR OIL ENGINES.

in special clips when the pump is not required. The belt is shown in the "stored" position in Fig. 10. The complete unit is quite compact, the overall length being 27 in., the width 13 in., and the height 20½ in. It is mounted on a substantial bedplate and although it has been introduced to meet the requirements of country dwellers, it can be used with equal facility on yachts and house-boats.

ELECTRIC HAMMER MILL.

Scottish Mechanical Light Industries, Limited, 42-44, Waggon-road, Ayr, Scotland, were demonstrating a selection from their extensive range of hammer mills, including their new electrically-operated unit known as the Scotmec Electromatic hammer-mill. This unit is illustrated in Fig. 11, where it is shown connected to a multi-bagging machine. As will be seen from the illustration, the motor is disposed vertically and the casing of the mill is flange-mounted to the motor casing. The grinding rotor and fan are fitted to an extension of the armature shaft, the bearings for which are designed to accommodate the extra thrust. Two sizes of motor are available, namely, a 3-h.p. unit for single-phase operation and a 5-h.p. unit for three-phase operation. The rotor is of the swinging-hammer type and is designed to operate at 3,000 r.p.m. The screen surface extends round the full circumference of the grinding chamber and a range of 11 screens with perforations from $\frac{1}{16}$ in. to 1 in. is available for use with the machine.

The multi-bagging unit, designated the Multi-Bagger by the manufacturers, consists of a 3-ft. diameter drum supported on legs. An air-release filter is installed in the top of the drum and the base of the drum is provided with six bagging-off outlets, each fitted with a separate closing flap. The bags are fastened to the outlets before grinding is started and the meal, as it is ground, is blown centrally into the drum, which distributes it equally into the six bags. With the six outlets in use, the unit is capable of dealing with from 8 to 12 cwt. of meal, depending on the kind of grain being milled.

The manufacturers have also developed a control panel for use with the Electromatic hammer mill. The panel incorporates an ammeter, a control switch and an automatic power cut-off. The last-named consists of a relay which is fitted into the power circuit and arranged so that the current is cut off as soon as the load is removed from the motor, that is, when no grain is entering the grinding chamber. Selection of either automatic or straight-forward control is made by means of the control switch referred to previously.

PORTABLE AIR COMPRESSOR.

An addition to their range of air compressors was shown by Maxim Engineering, Limited, Charvil Works, Bath-road, Twyford, Berkshire. The new compressor, which is known as the P.U.P. Major, is illustrated in Fig. 12. As its name implies, it is much larger than the Junior and Standard models made by the same firm, having a displacement of 13½ cub. ft. per minute and a maximum operating pressure of 150 lb. per square inch. The compressor is driven through a V-belt from a J.A.P. 3½-h.p. air-cooled single-cylinder engine designed to operate on petrol or paraffin. A twin-cylinder compressor is used, the cylinders being arranged in V formation and bolted to a rigid crankcase. Each cylinder is fitted with an air filter and care has been taken with the design of the lubricating system to ensure oil-free air. Tubular air receivers are used and, as will be seen from the illustration, these form part of the chassis. They are fitted with a combined safety and pressure-regulating valve, a pressure gauge and the usual drain cocks. Two outlets are provided and the unit is of sufficient capacity to operate two spray guns or lances. The complete unit is mounted on 20-in. by 3-in. pneumatic tyres for easy transport, but the design is such that it can be fitted with a special transport carrier which permits it to be mounted on a tractor when it is required to convey the unit an appreciable distance. The output of the compressor is sufficient to operate a wide variety of tools and appliances, such as the Shearomatic hedgecutter, pneumatic drills, chisels, etc.

STARTER MOTOR FOR OIL ENGINES.

The increase in the use of Diesel engines as prime movers for tractors and agricultural machinery generally has led to the development of special ancillary equipment. C.A.V., Limited, Acton, London, W.3, for instance, have developed, and were showing at Earl's Court, a new starter motor designed primarily for use on tractors and vehicles fitted with oil engines of medium size. Known as the type SO45, the new starter is illustrated in Fig. 13. It is of robust construction and differs from the well-established axial and inertia types of starter in that the pinion is engaged by means of a forked lever operated by a solenoid mounted on the yoke. The solenoid has three functions, namely, to bring the pinion slowly into mesh with the gear ring on the flywheel, to limit the current during initial engagement, and to place the starter on full load when completely engaged. When the starter switch is operated, the solenoid is energised and the pinion brought forward towards the gear ring. At the same time, a limited amount of current is passed through the series-field windings, thus permitting slow rotation of the armature. Should, therefore, the pinion and flywheel gear ring abut tooth to tooth, the armature will rotate for a few degrees so as to permit smooth, shock-free engagement of the teeth. The main contacts are not allowed to close until the pinion is almost fully home; therefore the starter cannot exert its full power until the pinion and gear ring are fully in mesh. The motor has a series field and wave-wound armature, and a multi-plate clutch is incorporated between the armature and pinion to provide a safeguard against damage due to overloading. The starter is 4½ in. in diameter and is made for flanged outboard mounting only.

(To be continued.)

"DEVELOPMENT OF THE WRIGHT FLYER": ERRATA.—In our article on the Wright brothers and their aircraft, it was stated on page 737, *ante*, that both Wilbur and Orville Wright were born in Dayton, Ohio; but on page 753, *ante*, that Wilbur was brought to Dayton in infancy. The latter statement is correct; Wilbur was born in Millville, Indiana. In the caption to Fig. 4, on page 739, *ante*, the date of the meeting of King Alfonso of Spain with the Wrights at Pau was given as 1908. We have since ascertained that the actual date was February 20, 1909.

LABOUR NOTES.

PLEAS that a new conception of industrial democracy should be introduced, leading away from existing ideas regarding class distinctions, "sides" and "areas of conflict," were put forward by Sir Walter Monckton, the Minister of Labour and National Service, at the annual dinner of the Industrial Welfare Society in London on December 9. Sir Walter considered that such a conception was essential if the country were to surmount without conflict what was sometimes referred to as the second phase of the industrial revolution.

A gradual development of the old employer-workpeople relationship into something much nearer to the idea of membership of a working team would do much to help the country on its way. That might seem like a distant dream, Sir Walter said, but, in spite of discouragements, he felt that it could be made a reality. Such a change could not be brought about by Government action, or by the unaided efforts of workpeople or employers. It called for a greater measure of give and take and of working together, than it had so far been possible to achieve, even in this country's industrial structure. Further, it should be generally recognised that no one could afford to go back to outworn methods of discipline, or to practices which had as their objective the furtherance of sectional interests.

As anticipated in our last issue, the executive council of the Confederation of Shipbuilding and Engineering Unions decided at their meeting at York on December 10 to postpone a decision on the proposals to ban overtime and piece-work in the engineering and shipbuilding industries. It was announced after the meeting that a special conference of executive officials of the 39 unions affiliated to the Confederation would meet in London on December 23, to decide on the next steps to be taken in the dispute over the employers' rejection of the Confederation's demands for an increase of 3*s.* in the pound in the wages of adult male employees in these industries. On the morning of December 23, the executive council will meet again to draw up recommendations for consideration at the conference.

A number of alternative courses of action appear to be open to the delegates at the conference, but it seems likely that, whatever they decide, the outcome of their deliberations will mean demands for a ban on overtime and for severe restrictions on piece-work. Difficulties have arisen over the proposals of the Amalgamated Engineering Union to ban piece-work completely and opinions among the various unions are by no means unanimous. In general, the craft unions, mostly small organisations catering for the more highly skilled operatives, consider that a total ban on piece-work is either undesirable or impossible, owing to the fact that, in the vast majority of cases, their members' earnings are based on payment-by-results schemes, which make no provision for time rates.

The executive committee of the United Patternmakers' Association, for instance, have declared their support for an embargo on overtime, but appear to be opposed to restrictions on piece-rate working. Another union, the United Boilermakers' Society, considers that it would not be practicable to put into operation a complete ban on piece-work. This union will put forward for consideration at the conference a proposal that organisations affiliated to the Confederation should be requested to consider restrictions on piece-work "and on any other systems of working which will further the purpose of the wage claims." The union also desires that there shall be an embargo on overtime in all establishments, whether affiliated to the Shipbuilding Employers' Federation and the Engineering and Allied Employers' National Federation, or not.

It is possible that the conference will eventually decide upon a formula which will permit the various unions to enforce restrictions on piece-work in the way that suits them best. This would enable men employed under the terms of payment-by-results schemes to work for three or four days a week only, or until such time as their earnings amount to the equivalent of the industry's time rate. The representatives of the Transport and General Workers' Union are likely to ask for a ballot of members of the affiliated unions, on the issue of whether there should be a ban on overtime and piece-work or a request for a court of inquiry into the wage claims. The National Union of General and Municipal Workers would prefer a ballot on the two alternatives of whether there should be a strike or reference of the dispute to arbitration.

Warnings of the dangers of earnings lagging behind living costs are given by Mr. Ben Gardner, O.B.E., the general secretary of the Amalgamated Engineering Union, in the December issue of the union's *Monthly Journal*. More ominous of coming trouble than the country's trade prospects for the New Year, he states, are the unsettled wage problems of industry, including those of engineering employees and of many others. After five months of abortive negotiations, with four meetings between the executive council of the Confederation of Shipbuilding and Engineering Unions and the respective groups of employers, a complete deadlock has been reached on the wage claims. The situation is serious.

Mass demonstrations all over the country have been amazingly well attended and leave no doubt at all as to the feelings of engineering employees. Every wage increase over the last seven or eight years, apart from the difficulty and delay in securing them, has been less than sufficient to meet the cost of living as it then stood. This has meant an accumulating deficiency which has left engineering workpeople in a position where they are substantially worse off than they were at the termination of the war. And it is not, Mr. Gardner claims, that the engineering industry has been unable to meet the demand for better wages. The industry has had an unprecedented run of full employment.

Fears for the country's immediate trade prospects are also expressed by Mr. Gardner. He considers that the outlook for the New Year, both for the engineering industry and for the country's industries as a whole, is none too bright. Some pessimistic forecasts of the country's position in competition with others for the sale of goods in the world markets point to the possibility of another crisis in economic conditions throughout the world. Although the trade gap has been narrowing during the second half of the present year, there are indications of a block in British exports to North America and export prices have stopped falling. While industrial production has shown an upward tendency recently, the advance has been uncertain and uneven.

Repercussions of the one-day token strike on December 2 have continued. The new fashion, of refusing to speak to those who did not take part in the stoppage, which began with the decision to ignore for six months a crane operative at Chesterfield, has spread steadily, until, at the time of going to press, no fewer than 16 men have been subjected to such action. On December 9, some five hundred foundrymen at the Morris engine factory at Coventry passed a resolution pledging themselves not to fraternise with two non-unionists who continued at work during the strike. Some 70 workpeople who were discharged by their employers, the Winfray Engineering Company, Limited, Coventry, for joining in the strike, went back to work on December 9. It was announced that the firm and the unions concerned had reached an agreement on the matter. On the other hand, a small number of radio mechanics and electricians employed at the Sunderland factory of the Edison Swan Company, Limited, ceased work on December 9, owing to the failure of a non-union radio mechanic to observe the strike.

Leaders of the three principal railway unions met in London on December 10 and decided, after a long discussion, to reject outright the award of an increase of 4*s.* a week in the wages of adult male railway employees granted by the Railway Staff National Tribunal on December 4. According to recent estimates by the British Transport Commission, this increase, together with proportionate concessions for women and juvenile employees, would add some five-and-a-half million pounds a year to the wage bill of British Railways. Awards by the Tribunal, which represents the final stage in the railway industry's negotiating machinery, though not legally binding, are usually accepted by both sides, and it is believed that this is the first occasion in recent years on which a major award on wages has been rejected by one of the parties concerned. The award was accepted by the Commission on December 7.

Joint claims against the Commission had been entered originally by the Transport and Salaried Staffs' Association, the National Union of Railwaymen and the Associated Society of Locomotive Engineers and Firemen for an all-round increase of 15 per cent. on existing wage rates. This would have been equal to an advance in wages varying between 18*s.* and 26*s.* a week, according to grade. After the joint meeting on December 10, the trade-union leaders went to the headquarters of the Commission and informed Mr. W. P. Allen, the Commission's chief of establishments and staff, of their decision. A series of discussions between the trade unionists and members of the Commission took place on the following day, at which Sir Brian Robertson, Bt., the new chairman of the Commission, presided. It was stated to be his first meeting with the trade-union leaders across the conference table.

Unofficial go-slow action was taken last week in protest against the insufficiency of the railway-wage award. Some 3,000 railwaymen, principally in the Birkenhead district, commenced working to rule on December 9 and were joined on the following day by 5,000 goods and cartage men from other Merseyside depots. In all, 20 depots in the area were affected. The men expressed their intention of refusing to work for bonus rates, or to do overtime, or perform Sunday duty.

It was announced on December 10 that official backing was being given by the Association of Engineering and Shipbuilding Draughtsmen to about 170 members of the union who were on strike at the aircraft factory of Messrs. Handley Page, Limited, Cricklewood, London, N.W.2, and that strike pay was being granted to them. The stoppage, then in its sixth week, started over the employment of trainee staff, and, subsequently developed into a dispute on minimum rates of pay. The Association is endeavouring to secure the acceptance of its own scale of remuneration, which ranges from 7*l.* 17*s.* 6*d.*, for employees aged 21, to 10*l.* 15*s.* for those aged 25 and above.

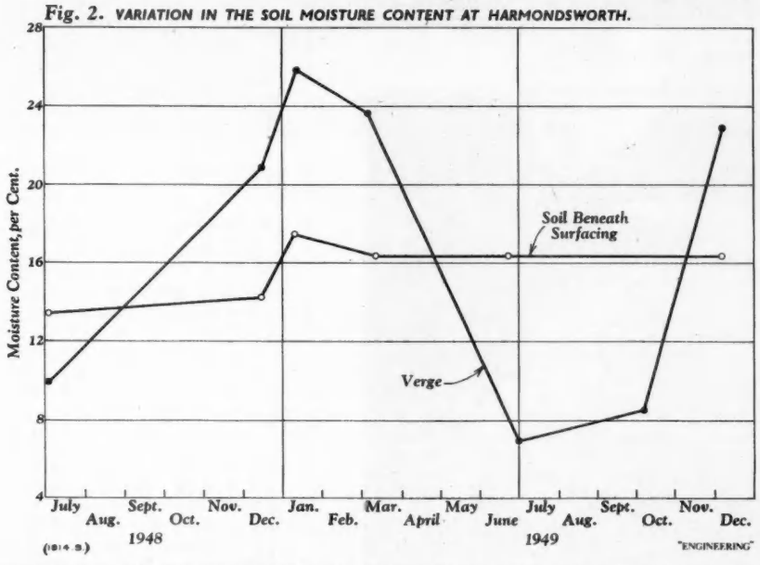
Senior members of the Civil Service are to receive substantial advances in their rates of pay. By the terms of an award of the Civil Service Arbitration Tribunal, announced on December 9, first division civil servants have been granted salary increases of up to 195*l.* a year. Through their negotiating body, the Association of First Division Civil Servants, they had claimed a scale of remuneration rising from 1,600*l.* to 2,200*l.* a year, by annual increments of 60*l.* The Treasury had previously offered a scale rising from 1,105*l.* to 1,500*l.* a year. The award, which will be retrospective to January 1, 1953, is for a scale of 1,150*l.*, rising by 40*l.* a year to 1,190*l.*, and then by 50*l.* a year to a maximum of 1,570*l.* Government staff affected by the new scale number about 1,170 in all.

Delays to the Queen Elizabeth and other large passenger liners were caused by an unofficial strike of 160 tugmen at Southampton. The stoppage, which began on December 8, was settled two days later, after lasting for just over 40 hours. Difficulties arose over the composition of crews in two new oil-fired tugs belonging to the Red Funnel Line. The company considered that one fireman to each of the tugs was sufficient, but agreed, on the representation of the union concerned to employ two firemen to each vessel for a trial period.

SURFACE DRESSINGS FOR SOIL FORMATIONS.

FIG. 1. SURFACE-DRESSED SOIL ROAD AT HARMONDSWORTH AFTER SOME WEEKS' USE.

Fig. 2. VARIATION IN THE SOIL MOISTURE CONTENT AT HARMONDSWORTH.



SURFACE DRESSINGS FOR PROTECTING SOIL FORMATIONS.*

By W. A. LEWIS, B.Sc., A.M.I.C.E.

THE following article details four investigations which have been made on the use of various types of surface dressing in the protection of soil formations. The investigations were made at the following sites: in the grounds of the Road Research Laboratory, Harmondsworth, Middlesex (silty clay); Basildon, Essex (heavy clay); Mamhilad, Monmouthshire (marl); and Sapcote Junction, Leicestershire (silty clay). It is appreciated that, in addition to the work described, some authorities have also used the technique of surface-dressing soil in the course of normal road and airfield construction.

INVESTIGATION IN GROUNDS OF ROAD RESEARCH LABORATORY.

Site Details.—The experimental road was constructed to connect the site of a new asphalt plant to an existing road. It was approximately 140 ft. long and 12 ft. wide. Ditches, 1 ft. deep, were provided on either side with grips at intervals of 5 ft. to remove surface run-off. The subgrade consisted of a silty clay with average liquid and plastic limits of 45 and 23 per cent., respectively (extended Casagrande classification CI).

Construction of the Road.—The grass and top soil were stripped and the formation shaped to a 3-in. camber. As the surface of the subgrade had been loosened in places it was compacted by a few passes of a 2¾-ton smooth-wheeled roller. The formation was then primed with a tar having an equi-viscous temperature of 25 deg. C. (25-deg. E.V.T.) and spread at the rate of 3 sq. yd. per gallon, followed 24 hours later by a tack coat of 38-deg. E.V.T. tar (5 sq. yd. per gallon); ¼-in. Leicestershire porphyry chippings were then spread at a rate of about 140 sq. yd. per ton. The surface was resprayed with 38-deg. E.V.T. tar (5 sq. yd. per gallon) and covered with ½-in. Leicestershire porphyry chippings (about 100 sq. yd. per ton). The finished surface dressing was rolled with the 2¾-ton smooth-wheeled roller. The road was constructed during June and July, 1948, in hot, dry weather, and the subgrade was allowed to dry to a certain extent before the surfacing was applied. Fig. 1 shows the road after it had been open to traffic for some weeks.

Moisture Conditions in Subgrade and Verges.—Before the subgrade was surfaced, and at various times subsequent to the completion of the surface dressing, observations were made on the variation with depth of the moisture content of the subgrade, and of the soil in the verges. The variation in the average moisture content of the top 6 in. of soil beneath the surface dressing and in the exposed grass verges beyond the ditches, during the 18 months of the experiment, is shown in Fig. 2. From this drawing it can be seen that, after the hot, dry summer of 1948, the moisture content of the soil under the road increased to a value of about 17 per cent. and remained reasonably constant, whereas the changes in moisture content of the soil in the verge (7 to 26 per cent.) reflected the wet winters of 1948 and 1949 and the dry summer of 1949.

Performance of Road Under Traffic.—The road carried fairly heavy traffic from time to time during the period of the experiment, especially when lorries were bringing aggregate to the asphalt plant and removing the processed bituminous material. In general, it stood up to this type of traffic very well, surprisingly little deformation occurring, and the general appearance of the road was not very different from any surface-dressed macadam road. Serious deformation of the surface was caused, however, during the later period of the experiment, by the passage of some of the heavy units of the mobile asphalt plant (one unit weighed 22 tons), but this was considered to be an unduly severe test.

INVESTIGATION AT BASILDON, ESSEX.

Site Details.—The experiment at Basildon was carried out in March, 1951. The site was a short length of grass track, 156-ft. long and 30-ft. wide, on a heavy clay. Prior to the investigation, the track had been very badly churned up by traffic and was rutted to depths of from 12 in. to 18 in.; the initial conditions may be assessed from Fig. 3, on page 794. The ruts were filled with water after prolonged periods of rain, and generally the whole area was very water-logged as there was no provision for drainage. The south side, sheltered by a tall hedge, received little drying from the sun.

The results of tests, summarised in Table I, show that the subgrade was a heavy clay of high plasticity and of high natural moisture content. The value of 2 per cent. for the undisturbed California bearing ratio indicates an unusually low stability. The moisture content of the top 3 in. of the experimental road varied between 25 per cent. and 35 per cent.; this was probably due to water standing for long periods in the ruts of the original track so producing patches of softer and wetter clay.

TABLE I.—*Tests on Clay at Basildon.*

——	Average Value.	Limits of Error (9 Chances in 10).
Natural moisture content, per cent.	30	1·5
Liquid limit, per cent.	71	—
Plastic limit, per cent.	28	—
Plasticity index, per cent.	43	—
California Bearing Ratio Test.		
Undisturbed C.B.R. value, per cent.	2	0·5
Dry density, lb. per cub. ft.	88	1·5
Moisture content, per cent.	30	1·5
Unconfined Compression Test on Clay from Final Formation.		
Undisturbed unconfined compressive strength, lb. per sq. in.	14	1·5
Dry density, lb. per cub. ft.	88	1·0
Moisture content, per cent.	34	1·0

Preparation of Site.—The water in the ruts was drained to the far end of the site by ditching, and the clay formation exposed and given a 3-in. camber by stripping off the grass and topsoil to a depth of about 18 in., using a mechanical excavator with skimmer attachment. Final trimming was done by hand to give a roughly shaped formation. Ditches, about 6-in. deep, were provided at each side of the formation to carry away the surface water. The exposed formation was rolled with a 2½-ton smooth-wheeled roller to smooth surface irregularities.

Surface Dressings Used.—Surface dressing of the prepared formation was carried out immediately after rolling. A total of 14 sections were laid, each a half-width of the road, but of various lengths. As shown in Fig. 5, page 794, some of the sections were treated with a single dressing while others were given a double dressing. Before sections

* Communication from the Road Research Laboratory. The work described was carried out as part of the programme of the Road Research Board of the Department of Scientific and Industrial Research.

SURFACE DRESSINGS FOR SOIL FORMATIONS.

FIG. 3. SITE AT BASILDON BEFORE TREATMENT.

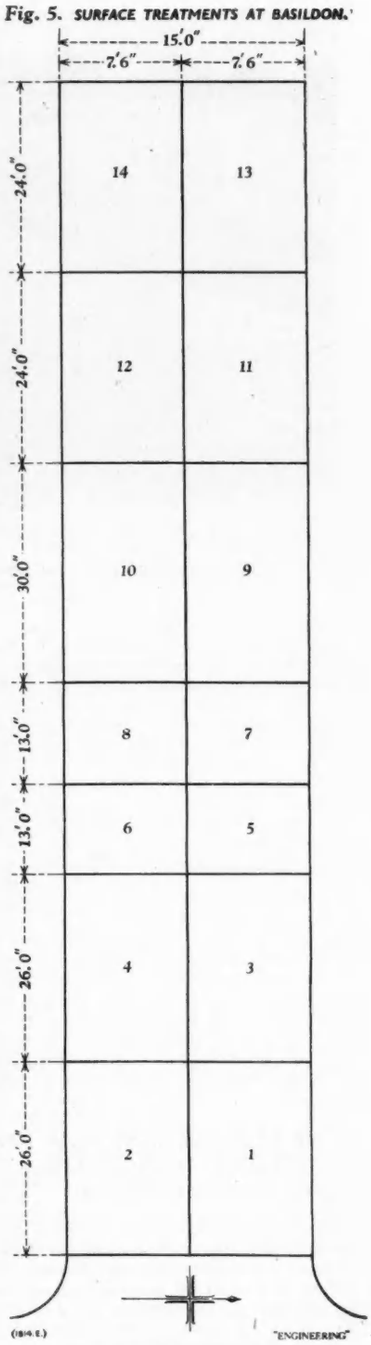
FIG. 4. SITE AT BASILDON AFTER TREATMENT.

9 and 10 were surface dressed, a single layer of ⅜-in. gravel was rolled into the prepared formations to find out if this would give the tar some additional key to the clay. One of the following three binders was used for each section: 30-deg. E.V.T. tar, type B; 38-deg. E.V.T. tar, type B; and a rapid-breaking bitumen emulsion, containing 62 per cent. of a 300 pen. bitumen (the viscosity of the bitumen being measured in terms of the depth of penetration —300 × 0·1 mm.—of a needle under standardised conditions).

The recommended tar for the time of the year had an E.V.T. of 30 deg. C., but it was decided to use a tar with a higher viscosity (38 deg.) as well, in view of the possible advantage of its being more resistant to disturbance by traffic. A bitumen emulsion was also included in the materials used because it possesses the advantage that it is applied cold. The aggregates used were ⅜-in. or ½-in. nominal-size local flint gravel, or washed pit sand.

The tar binders were sprayed at a temperature of 80 to 100 deg. C. by a hand-lance from a boiler of 100 gallons capacity, at a rate of approximately 4 sq. yd. per gallon. The bitumen emulsion was also sprayed by a hand-lance but, owing to the camber of the road, some drained to the sides leaving only a thin film on the crown. The aggregate was spread by hand shovel. Where a double surface-dressing treatment was used, the second dressing was applied immediately after the first. The surface dressings were rolled with the 2½-ton roller. In the case of the double surface-dressings of sections 1 and 2, the first dressing received only one pass of the roller before applying the second dressing and rolling again. This treatment was too severe as the formation began to soften

Fig. 5. SURFACE TREATMENTS AT BASILDON.



SURFACE TREATMENTS.

1. Double Dressing: (i) 38-deg. E.V.T. tar + sand; (ii) 38-deg. E.V.T. tar + ⅜-in. gravel.
2. Double Dressing: (i) 38-deg. E.V.T. tar + ⅜-in. gravel; (ii) 38-deg. E.V.T. tar + ⅜-in. gravel.
3. Double Dressing: (i) 30-deg. E.V.T. tar + sand; (ii) 30-deg. E.V.T. tar + ⅜-in. gravel.
4. Double Dressing: (i) 30-deg. E.V.T. tar + ⅜-in. gravel; (ii) 30-deg. E.V.T. tar + ⅜-in. gravel.
5. Single Dressing: 30-deg. E.V.T. tar + sand.
6. Single Dressing: 30-deg. E.V.T. tar + ⅜-in. gravel.
7. Double Dressing: (i) Emulsion + sand; (ii) Emulsion + ⅜-in. gravel.
8. Double Dressing: (i) Emulsion + ½-in. gravel; (ii) Emulsion + ½-in. gravel.
9. (i) ⅜-in. gravel rolled in; (ii) Single dressing of 38-deg. E.V.T. tar + ⅜-in. gravel.
10. (i) ⅜-in. gravel rolled in; (ii) Double dressing of 38-deg. E.V.T. tar + ⅜-in. gravel.
11. Single Dressing: 38-deg. E.V.T. tar + sand.
12. Single Dressing: 38-deg. E.V.T. tar + ⅜-in. gravel.
13. Single Dressing: Emulsion + sand.
14. Single Dressing: Emulsion + ½-in. gravel.

SURFACE DRESSINGS FOR SOIL FORMATIONS.

FIG. 6. COMPARISON BETWEEN TREATED AND UNTREATED SECTIONS, BASILDON.

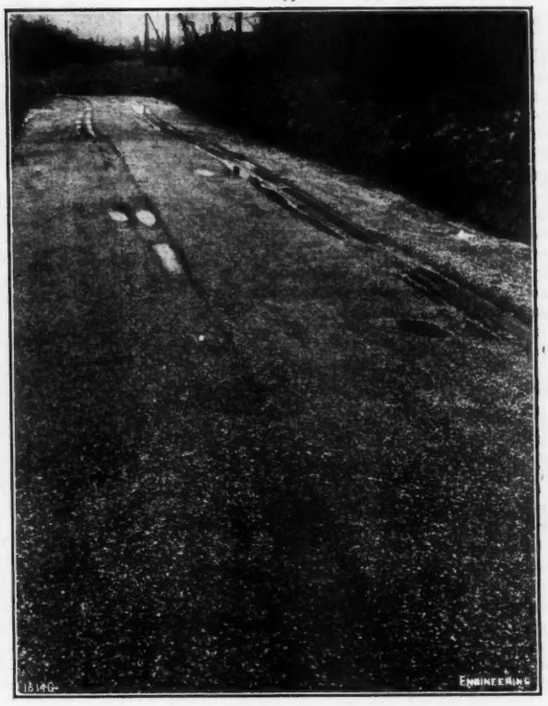


FIG. 7. ROAD AT BASILDON AFTER PASSAGE OF HEAVY LORRY.

and deform; thereafter, in all cases of double dressing, rolling of the first dressing was omitted.

The boiler was mounted on a lorry for convenience, which required the lorry to travel on the completed sections to reach those under construction. Although it was not heavily loaded, it caused rutting, especially in the weaker areas. During the whole of the construction, this and the roller were the only vehicles allowed to use the road and neither was allowed to stand on the formation when not in use.

Observations.—After the work had been completed, the site was closed to traffic for about two weeks. During this time the weather was very bad, the rain being quite heavy and continuous for long periods.

Determinations of moisture content after this time showed that the average moisture content of the top 3 in. of the surface-dressed formation had increased from 30 per cent. (limits of error, $\pm$ 1·5 per cent.) to 34 per cent. (limits of error, $\pm$ 1·0 per cent.). Statistical analysis shows that this is a significant increase of 3 per cent. This increase could have resulted, even in the absence of rain, from the removal of the overburden and the remoulding of the top few inches of clay formation. Visual inspection showed that the surface dressings had effectively sealed the surface and prevented rain from penetrating into the formation. In comparison, it should be noted that, after rain, untreated sections of the prepared formation were quickly reduced to an unworkable quagmire (moisture content estimated to be between 60 and 70 per cent.) by foot traffic alone; this is illustrated in Fig. 6.

The prevailing weather conditions were so poor that, in general, they prevented immediate adhesion of the gravel to the binder films and proper adhesion of the gravel sometimes took two or three days; under these conditions, the hot tar was more effective than the bitumen emulsion as a binder, though the latter was found to be satisfactory as a thin sealing coat, when subjected to no disturbance by vehicles. No advantage was found in rolling gravel into the surface of the formation to improve the adhesion of the binder. Gravel appeared preferable to sand as a blinding material because it provided some mechanical stability—an advantage where traffic is concerned.

The strength of the soil formation was very low, and it was not expected that the road would stand up to traffic. Three weeks after the surface dressings were completed, however, it carried a private motor car and a light laboratory van without serious deformation of the surface, with the exception of the sections treated with bitumen emulsion. However, a double pass of a heavily laden lorry (total weight 7 tons) caused considerable rutting in all the sections, as may be seen from Fig. 7, herewith. The double dressings were more effective than the single dressings in protecting the formation from the effects of weather.

INVESTIGATION AT MAMHILAD.

Site Details.—While carrying out improvements to the Newport-Shrewsbury trunk road (A472) at Mamhilad, the Ministry of Transport took the opportunity to investigate the value of surface dressings, among other methods, to protect a formation of red marl from the effects of weather and construction traffic. The work was carried out in June, 1950. The red-marl subgrade had a liquid limit of 32 per cent. and a plastic limit of 20 per cent. In the undisturbed state, the soil was very compact and contained a considerable amount of hard nodular material. The soil had a natural moisture content of about 14 per cent. and a dry density of about 122 lb. per cubic foot. It was found that remoulding while wet (which would have occurred under construction traffic) caused the soil to become unstable and it was important to prevent this by protecting the subgrade.

Details of Surface Dressings.—Four small areas of the formation, each approximately 17 sq. yd. in area, were treated as specified below and summarised in Table II.

Test Area No. 1.—A surface dressing using bitumen emulsion (62 per cent. bitumen), at 3 sq. yd. per gallon, was brushed on to the soil surface, which had previously been brushed clean but which was in a slightly damp condition. The area was then covered by $\frac{3}{8}$-in. clean dry broken limestone free from fines and dust, spread at approximately 120 sq. yd. per ton. An attempt to roll this first coat with a 2½-ton footpath roller failed on account of adhesion of the stone to the roller, but a 5-cwt. hand-roller was used successfully. The second coat was a repeat of the first and was also rolled with the 5-cwt. roller. The result was a good strong surface dressing.

Test Area No. 2.—This was a repetition of Test No. 1 except that a small amount of fines and dust (about 10 per cent.) was introduced into the $\frac{3}{8}$-in. limestone chippings. This had the effect of increasing the tendency to strip when rolling even with the light hand-roller; nevertheless, by using the roller carefully, both dressings were successfully rolled. The result was a medium-textured surface of good appearance.

TABLE II.—*Surface Dressings used at Mamhilad.*

Area No.	Treatment.	Type of Stone Used.
1	Two-coat surface dressing with bitumen emulsion applied by brush.	$\frac{3}{8}$-in. limestone chippings free of fines and dust.
2	As for Area No. 1. ..	$\frac{3}{8}$-in. limestone chippings with 10 per cent. fines and dust.
3	As for Area No. 1. ..	$\frac{3}{8}$-in. limestone chippings with 20 per cent. fines and dust.
4	Single-coat dressing with hot tar pressure-sprayed.	$\frac{3}{8}$-in. limestone chippings free of fines and dust.

Test Area No. 3.—This was a repetition of the previous tests with the exception that approximately 20 per cent. of fines and dust was added to the $\frac{3}{8}$-in. chippings. The additional fines seemed to increase the tendency of the first course to strip, but the second course was rolled without difficulty, The resulting dressing had the appearance of a dusty close-textured surface.

Test Area No. 4.—This section was a single-course surface dressing using type-A tar (32-deg. E.V.T.). The surface conditions were as described for the three sections above. The tar was applied at 250 deg. F. with a pressure lance from a Coleman spraying machine at a rate of 5 sq. yd. to the gallon and the surface then covered with $\frac{3}{8}$-in. limestone chippings free of fines and dust; the area was finally rolled with a 2½-ton footpath roller. Under the conditions of this test, this section was as good

as the best of the sections treated with the bitumen emulsion.

Discussion of Tests.—The method of applying emulsion with a brush was unsatisfactory. As is generally known, pressure spraying, as used on test area No. 4, is more efficient and economical than brushing. During the night following the day on which the first three test strips were laid, they were subjected to very heavy thunderstorms and test strip No. 3, located on the low side of the superelevation, was flooded for a period of some 10 to 12 hours. Intermittent heavy rain continued for many weeks and, during this period, traffic was kept off the strips. Ultimately, constructional traffic was run over the test areas for a period of several months with no apparent detrimental effect.

Test area No. 1 was considered the most satisfactory of the three bitumen-emulsion dressings. Unlike the bitumen-emulsion dressings, the tar-dressing showed no tendency to adhere to the roller. The area was opened to traffic after 24 hours and no deterioration was noted after four months' use by light construction traffic. Under the conditions of this test, the tarred section was as good as the best of the three bitumen-emulsion sections.

Investigation at Sapcote Junction.

Site Details.—As part of the preparation of the clay subgrade of an experimental section of road at Sapcote Junction, Leicestershire (on A46), the soil was surface-dressed. The subgrade was a silty clay having a liquid limit of 40 per cent. and a plastic limit of 20 per cent. The natural moisture content was about 14 per cent.

Details of the Surface Dressing.—The formation was sprayed with 38-deg. E.V.T. tar using a hand-lance and then blinded with ⅜-in. limestone chippings. No precise control was kept on the rates of spread but they were of the order of 3 to 5 sq. yd. per gallon and 100 to 120 sq. yd. per ton, respectively. Only a single dressing was used. The experimental section formed part of a large improvement scheme and the formation of the non-experimental length was given no protective treatment.

Behaviour of the Surface Dressing.—The work on the improvement scheme was carried out in the autumn of 1951. Bad weather set in before the bases and surfacings could be laid and work on the non-experimental length of formation which was not surface-dressed was seriously delayed through the softening of the subgrade. On the other hand, the subgrade of the experimental section which had been treated with a surface dressing was adequately protected from the effects of weather and laying of the bases and surfacing proceeded normally.

Conclusions.

The results of the investigations showed that a satisfactory waterproof layer could be produced by the surface-dressing technique. Tar was more effective than bitumen-emulsion binders as it was possible to obtain a much thicker waterproof film with one application. A single dressing using tar was as effective as a double dressing using a bitumen-emulsion binder. Although little information was obtained regarding types of aggregate, chippings seemed to be more satisfactory than sand. Where the subgrade had a sufficient strength to carry the wheel loads without serious deformation, the surface dressings were not damaged by construction traffic. As would be expected, a double application of surface dressing was better than a single application for carrying traffic and maintaining a waterproof layer.

The Late Mr. Walter A. Barnett, M.B.E.—It is with regret that we learnt of the death of Mr. Walter A. Barnett, M.B.E., M.I.Mech.E., M.Inst.GasE., who, at the time of his death on December 4, was divisional distributing engineer to the Kent County Division of the South-East Gas Board. Mr. Barnett was born at Greenwich, London, S.E.10, on September 25, 1891, and was educated locally and at evening classes. In 1906, he was apprenticed to the firm of I. H. Storey & Co., mechanical and electrical engineers. Thereafter he held successive posts with the South Metropolitan Gas Co., the Air Ministry (for one year only) and the Gas, Light and Coke Co., before being appointed in 1920 as Assistant Engineer and Works Manager to the Barnet District Gas and Water Co., Hertfordshire.

STORAGE SHED OF TIMBER CONSTRUCTION.

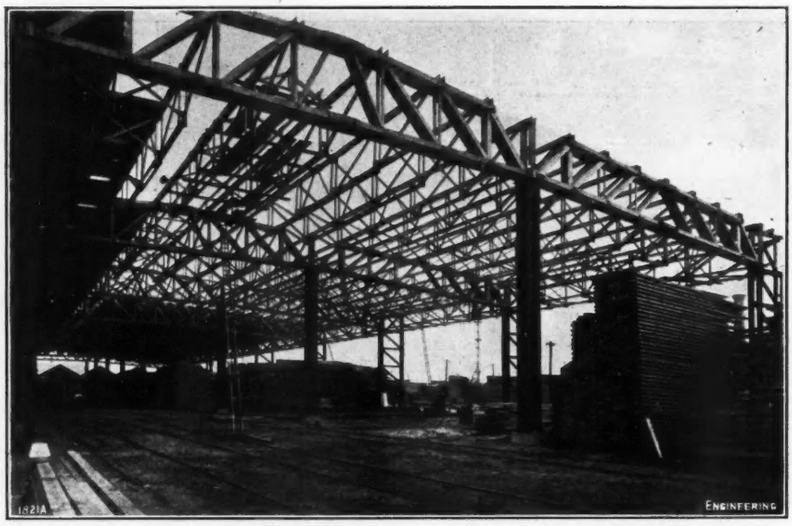


Fig. 1. The Main Framework.

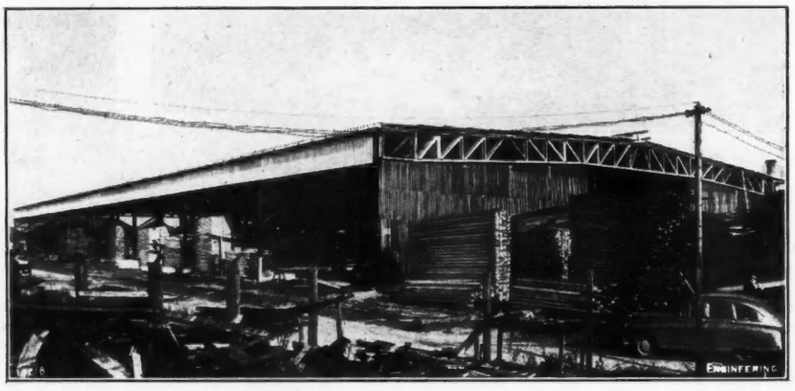


Fig. 2. Completed Shed.

STORAGE SHED OF TIMBER CONSTRUCTION.

A storage shed which is constructed throughout of timber has recently been completed for the timber-importing firm of Horsley, Smith and Company, Limited, at the Victoria Docks, Hull. The new shed, to be known as the "Coronation Shed" and depicted in Figs. 1 and 2, herewith, replaces earlier sheds demolished by fire during bombing raids in the last war. The old sheds were also of timber and a comparison between the old and new illustrates the developments in timber construction that have been made in recent years. Many of the features embodied in the new structure are the result of the work done at the Forest Products Research Laboratory, Princes Risborough, and by the Timber Development Association, Limited, 21, College-hill, London, E.C.4.

The old sheds were built about 40 years ago of redwood, Douglas fir (which had been creosoted under pressure), and, in some of the supporting columns, pitch pine. Except for some slight deterioration near the ground, they were reported to be in an excellent state of preservation at the time of their destruction, when they were nearly 30 years old. They had never required painting and the annual expenditure on their maintenance had been negligible. The structural timber used, excluding the side cladding, had amounted to 50·5 standards per acre (1 standard in 165 cub. ft.) and there were 134 columns to the acre. The clear height below the eaves was 22 ft.

The new shed, covering an area of 1⅞ acres, is built in the form of a rectangle 440 ft. long by 163 ft. wide and has an unrestricted height throughout of 25 ft., there being only 14 internal columns spaced at intervals of 55 ft. In all, there are 36 columns, say 22 columns to the acre, which is about one-sixth of the number used in the previous sheds. The total quantity of constructional timber used (again excluding side cladding) was 46·4 standards per acre, which represents a reduction of about 8 per cent. on that used previously.

The railway lines serving the new sheds are under cover and, together with a lorry road, run the full length of the centre of the building. This will enable the gangs engaged in piling away the wood to continue work in all weathers and will, furthermore, ensure that the wood is kept dry during the time it is being loaded and unloaded. In considering the layout of the sheds, care was taken to keep the arrangements as flexible as possible so that any future developments in mechanical handling could be readily adopted.

The selection of timber as the structural material was a natural one for the clients concerned, but timber was also found to possess several advantages over other materials. For example, as the site adjoins the River Humber, it was estimated that a steel building subjected to the corrosive action of the sea air and of the industrial atmosphere would require painting every four or five years at a cost, at to-day's prices, of about 1,500*l*. The timber shed, on the other hand, will not require painting or other maintenance, and it was found that building costs were about equivalent to those of a comparable steel building. Douglas fir, seasoned but otherwise untreated, and graded for working stresses of the order of 1,200 lb. per square inch, was chosen

for all structural work and the designs were made in accordance with British Standard Code of Practice, C.P. 112, "The Structural Use of Timber in Buildings."

The columns and roof girders were set out and prefabricated at the works of Boltwood Engineering, Limited, Wittingdon Moor, Chesterfield, who were responsible, with the assistance of their consultant, Mr. R. T. Walters, for the detailed design of the structure. A general idea of the size of the members can be gauged from the internal stanchions in the foreground of Fig. 1; these stanchions consist of four 8-in. square timbers with appropriate bolted connections and separators. The exterior stanchions comprise two posts at about 8-ft. centres, counter-braced by 4-in. by 6-in. diagonals, the inner post being of two 8-in. by 8-in. timbers and the outer, two 8-in. by 8-in. timbers at 8-in. centres. All the stanchions are founded on reinforced-concrete footings which, as can be seen from Fig. 1, protrude above ground-level, so safeguarding the feet of the timber stanchions from damp. The foot connection consists of 8-in. by 4-in. rolled-steel angles, with a ½-in. mild-steel bearing plate between the concrete and the timber.

The principal girders, spanning between the stanchions, are built up chiefly from 8-in. by 3-in. members, the top and bottom booms each consisting of three such members and, at the ends where the shear forces are large, the diagonals are made from four such members. The verticals are two 4-in. by 2-in. scantlings. The secondary girders are trussed purlins with the roof sheeting resting directly on the upper member, which is two 7-in. by 3-in. timbers close bolted, with appropriate trussing and counter-bracing between adjacent girders. The roof sheeting is "Universal" reinforced asbestos-cement troughing laid to a 4-deg. crossfall. Running the full length of the crown of the roof is a patent-glazing monitor. The finished shed is shown in Fig. 2.

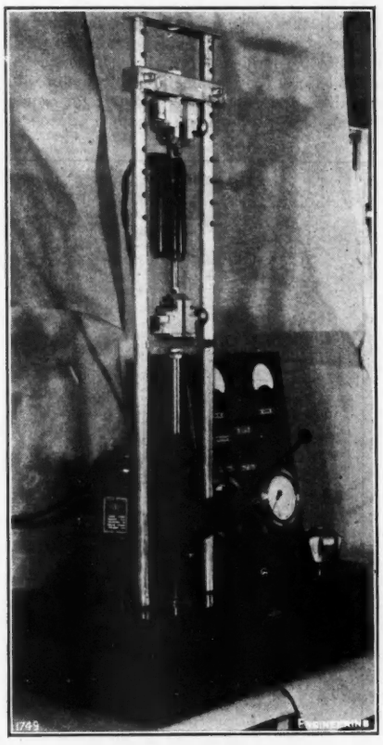
It is claimed that the fire endurance of the Coronation Shed—that is to say, the period for which it would withstand the effects of fire before collapse—is at least 2½ times as great as that of unprotected steel and about five times that of structural light alloys. This is explained by the fact that, though wood burns while metals do not, the strength of metals falls off rapidly with a rise of temperature whereas that of wood does not. Thus, at 800 deg. C., the maximum temperature of the "standard fire," structural components of metal fail by collapse, but timber members of reasonable thickness will continue to sustain their load though they may be charred on the surface. The layout of the shed has been so planned that the structure is accessible from all sides, and a fire engine can be driven down the central roadway which is 43 ft. wide. With the River Humber itself only 30 yards away, the dangers of fire are diminished.

The whole of the erection was speedily carried out without difficulty using only local labour. The main building contractors were Houlton and Grant, Limited, 73, Beverley-road, Hull. A crane was used for the erection of the columns, main beams and purlins, the columns taking an average of 20 minutes each from the time of lifting to final plumbing and securing, and the main girders were put into position in an average time of 15 minutes. The erection of the whole building has in fact been carried out most rapidly. The contract was let on April 16 last; half the shed was ready by mid-August and almost the whole shed by mid-October, just over six months after the contract was let. The architect for the shed was Mr. J. P. Taylor, of Gelder and Kitchen, 120, Alfred Gelder-street, Hull.

ENDOWED PRIZES OFFERED BY THE ROYAL SOCIETY OF ARTS.—As the trustees of various endowments, the Royal Society of Arts are offering a number of prizes during 1954. The prizes include: the Howard Prize for Mechanical Motive Power, for a treatise on steam or other motive power; the Fothergill Prize for an essay on Fire-Prevention or Fire-Fighting; the Benjamin Shaw Prize for an essay or model describing a newly-devised method for improving industrial safety. Details of these and other awards may be obtained from the secretary of the Society, John Adam-street, Adelphi, London, W.C.2.

TEST RIG FOR ELECTRIC ACTUATORS.

FOR checking the working of 24-volt direct-current electrically-operated linear actuators, of 50 lb. to 1,200 lb. load capacity, Tiltman Langley Laboratories, Limited, Redhill Aerodrome, Surrey, have recently introduced the test rig shown in the accompanying illustration. It consists of a hydraulic ram used to load the actuator under test, the ram being supplied by pressure from a motor-driven pump and a fluid reservoir housed in a light alloy casing. Load can be applied to either side of the



ram through a four-way valve. The ram is mounted between guide bars which carry adaptors that can be adjusted to suit any type of actuator end-fitting. The ram is connected by one of these adaptors to one end of the actuator. The other end of the actuator is connected, through an adaptor, to a vertically-adjustable crosshead. Actuators up to 17½ in. long when extended can be accommodated, with a stroke ranging from ½ in. to 6 in. The universal adaptors have a range of hole sizes from ⅛ in. diameter to ½ in. diameter in 1/16 in. steps.

Two alternative load gauges can be switched into the hydraulic circuits as desired, one reading from 0 to 350 lb. and the other from 0 to 1,500 lb. A blow-off valve in the hydraulic circuit protects the low-pressure gauge from damage should testing at high pressure be attempted while it is connected in the circuit. A direct-current supply point is provided, and a voltmeter and ammeter indicate the power used by the actuator, which can be controlled electrically by an "extend and retract" switch. A push-button switch is also provided to enable small movements to be made over specified time intervals. A vernier gauge is available for measuring the stroke. Automatic cycling equipment can also be provided to allow endurance load testing to be carried out. The whole rig is enclosed in a portable cabinet 26 in. by 14 in. by 48 in.

NATIONAL PACKAGING EXHIBITION IN 1955.—Arrangements are being made to hold the next biennial packaging exhibition at Olympia, London, W.14, from January 18 to 28, 1955. The exhibition, as previously, will be organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester.

TRADE PUBLICATIONS.

Electricity in Weaving.—An illustrated booklet, entitled "Electricity in Weaving," has been published jointly by the British Electrical Development Association and the North Western Electricity Board. It contains a number of examples of the ways in which electricity is being used by textile manufacturers, including such little-known applications as broken-end detectors and electromagnetic braking systems. It also contains useful information on loom drives, metering and production control, as well as on lighting, air conditioning and materials handling. Copies can be obtained either from the North Western Electricity Board, Cheetwood-road, Manchester 8, or from the Electrical Development Association, 2, Savoy-hill, London, W.C.2.

Power from Process Steam.—Ashworth and Parker, Ltd., Riverside Works, Bury, Lancashire, have issued a booklet describing engines designed to work on process steam. Live steam is supplied to the engines, which either run with a back-pressure or else pass out the steam after the high-pressure cylinder, in either case the steam coming out being at the right conditions for the processes involved. In the pass-out engine, when the steam is not required for processing it supplies power to the low-pressure cylinder.

Pneumatic Equipment.—We have received from Broom and Wade, Ltd., High Wycombe, three illustrated leaflets depicting pneumatic tools and motors for mechanical engineering, civil engineering, and foundry duties, respectively.

Self-Locking Nuts, Fasteners, etc.—Aero Controls Ltd., Industrial Estate, Weedon-road, Northampton, have issued a series of leaflets describing briefly their stud-type self-locking fasteners and toggle-type flush fasteners for securing cowling panels, the latter being capable of withstanding high air load, and their Martin self-locking nuts.

Plastics.—Bakelite,, Ltd. 12-18, Grosvenor-gardens, London, S.W.1, have issued three leaflets; two describe briefly the application of Bakelite Laminated to jigs and tools, and to various purposes in the aircraft industry, and the third gives a specification of Vybak industrial rigid polyvinylchloride sheet, a tough thermoplastic sheet of exceptional chemical resistance which can be machined by methods similar to those used for sheet metals.

Petroleum.—The Iraq Petroleum Co., Ltd., 214, Oxford-street, London, W.1, have issued an illustrated brochure entitled "Iraq Oil in 1952," describing the company's development during 1952.

Cabin Atmosphere Control.—Normalair Ltd., Yeovil, Somerset, have issued a well-illustrated booklet giving detailed technical descriptions of their equipment for the pressure control, air-flow control, humidification, and heating of aircraft cabins, and their oxygen equipment.

Aluminium.—We have received from Aluminium Ltd., Montreal, Canada, a well-produced 126-page bound and illustrated volume describing the activities of the company.

Box and Swivel Angle-Plates.—James Neill & Co. (Sheffield), Ltd., Napier-street, Sheffield, 11, have issued two pamplets, one giving details of their three sizes of box angle-plates and the other dealing with the two swivel angle-plates which they manufacture.

Materials Handling Equipment.—A catalogue published by Willmot Trucks, Ltd., Ivanhoe Works, Scotts Green, Dudley, illustrates their range of industrial "Tuglift" trucks. Tow-bars fitted with wheels and a coupling for raising the front end of the trucks are also listed.

X-Ray Fluoroscopy.—Solus-Schall Ltd., 18/22, New Cavendish-street, London, W.1, have published a booklet describing their fixed and mobile industrial fluoroscopic equipment. This is suitable for inspecting light-alloy castings up to 1¼ in. thick, welds or assemblies. The turntable on which the specimen rests can be rotated and raised or lowered during inspection. The screen of the mobile unit is 8¼ in. by 8¼ in., and that of the fixed model is 14 in. by 14 in. Provision is made for film cassettes.

Contractors' Equipment.—Catalogues and leaflets published by George Pike, Ltd., Equipment Works, Alma-street, Birmingham, 6, describe various equipments for the public-works contractor. Lights, tools and shelters are included. One leaflet describes a hand-operated spring-driven road breaker.

Agricultural Tractors.—We have received a leaflet from David Brown Corporation (Sales), Ltd., Tractor Division, Meltham, Yorkshire, written to assist the farmer in assessing the merits of Diesel and vaporising-oil engines in relation to his needs. It shows by simple calculation that the David Brown 30D Diesel engine must be operated for 900 hours per year before it becomes more economical than their 30C vaporising oil engine. Details are also given of the effect of servicing and spare parts on the running cost.

EXPERIMENTAL WAGONS OF ALUMINIUM CONSTRUCTION.

Although it is in transport that the advantages of aluminium as a constructional material are most obvious, its adoption for railway rolling stock, especially goods wagons, has so far been on a comparatively small scale, mainly, perhaps, because it is not easy in practice to prove that there will be any immediate benefit from making such a change in construction material.

A prototype wagon, however, has now been in service with British Railways for over seven years, it having been taken over from a private owner at the time of the nationalisation of the railways. This wagon was constructed at the works of the Cambrian Wagon and Engineering Company, Limited, Maindy, Cardiff, and aluminium was used for the plating only, the Northern Aluminium Company, Limited, Banbury, giving advice on the choice of alloys and thicknesses of plate, which it was decided should be the same as the steel plate normally used. Apart from a saving in tare weight of 25 cwt., a survey made jointly by British Railways, the Aluminium Development Association, and Aluminium Laboratories, Limited (on behalf of the Northern Aluminium Company) has shown that the plating was in sound and serviceable condition after seven years of use during which the wagon has been employed in the carriage of coal and coke, and contrasted very favourably with that of steel wagons of the same age in the same service.

Surface attack was very slight and confined to the underside of the floor and the lower edges of the sides, while localised corrosion had taken place only in a few isolated instances where dust and moisture had become trapped between the steel angles and the aluminium plating. It was obvious, however, from the condition of the interior of the wagon, that it had many more years of service before it, and the complete absence of scale was particularly noticeable.

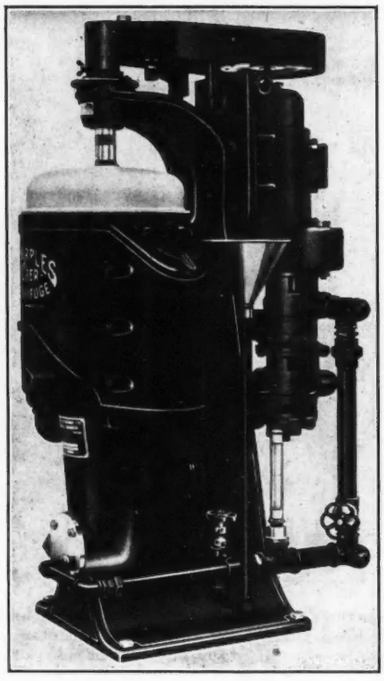
Another aluminium wagon has recently been built by the same company for the Nyasaland Railways. In general appearance it closely resembles a normal 35-ton high-sided wagon of steel construction, 60 of which have recently been completed for these railways. The body, however, is half of steel and half of aluminium alloy. The use of the two metals side by side, while ensuring that service conditions remain identical, should enable the users to assess to what extent the use of aluminium alloy is justified by the reduced painting costs to be expected from the corrosion-free properties of this material.

For one half of the wagon, aluminium plating has been substituted for steel plating in the floor, sides, and end, and for the fabrication of the doors; aluminium extrusions have been used for the end-plate stiffeners. The aluminium plate used is Noral 65 SWP, a fully heat-treated alloy having a typical 0·1 per cent. proof stress of 17·5 tons per square inch, supplied by the Northern Aluminium Company. Direct substitution, thickness for thickness of steel plate, was made except for two floor plates, where $\frac{7}{8}$ in. aluminium plate has replaced a $\frac{1}{4}$-in. steel plate, but with the provision of additional steel angle sections welded in the underframe to give further support to the floor, particularly in the areas by the doors. Extruded sections of Noral 51 SWP were used for the end-plate stiffeners, corner angles, and the top-capping along the sides, but for the door frames and the side stanchions standard steel components were used. Aluminium rivets in Noral 16 ST were used for making the aluminium-to-aluminium and also the aluminium-to-steel joints at the lower edges of the side and end plates: all other aluminium-to-steel joints were made with hot-driven steel rivets. Zinc-chromate jointing compound was applied to all bi-metallic joints to prevent galvanic corrosion, and all steel-work adjacent to aluminium was finished in an aluminium paint. It is stated that had the entire body been of this form of aluminium construction, a saving of about 32 cwt. in the tare weight of the wagon would have been effected.

CENTRIFUGE FOR HEAVY FUEL OILS.

The latest addition to the range of industrial centrifuges manufactured by Sharples Centrifuges, Limited, Tower House, Woodchester, Stroud, Gloucestershire, is the 18V machine, shown in the accompanying illustration, for purifying heavy fuel oil, etc. It is completely enclosed to minimise the escape of vapour during centrifuging, and is designed for throughput rates up to 1,000 Imperial gallons per hour. The rotor is driven by a 3-h.p. electric motor through a fabric belt provided with automatic tensioning mechanism.

In the Super-Centrifuge machines, it may be recalled, the rotor consists of a hollow cylinder, rotated at a speed of 15,000 r.p.m., into which the liquid to be purified is introduced through an inlet at the base of the machine. Two types of rotor are available—the "separator" type, for separating two immiscible liquids and removing any suspended



solids contained in them, which has two sets of outlets at the top for discharging the separated liquids; and the "clarifier" type, used where it is only desired to remove the suspended solids from a single liquid and, therefore, employs only one set of discharge ports. Under the action of centrifugal force, the heavier solids are deposited on the rotor wall and, in the case of a mixture of two liquids, the latter are formed into concentric cylindrical layers, the lighter liquid being nearer the axis of the rotor. In the 18V machine illustrated, the rotor may be of tinned steel, stainless steel, Monel metal or Inconel. The inlet ports are of cast iron and brass.

The rotor is suspended from the drive-bearing assembly by a flexible rubber-mounted spindle. At its lower end, the rotor is carried in a loose-fitting guide-bushing which is cushion-mounted so that it may shift to allow the end of the rotor to take up its own position under the local conditions imposed by the uneven distribution of solids on its wall, thus avoiding the transmission to the bearings of vibratory loads resulting from rotor unbalance.

1954 Cycle and Motor Cycle Show.—The next Cycle and Motor Cycle Show, organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Warwick-road, Coventry, will take place at Earl's Court, London, S.W.5, from Saturday, November 13 to Saturday, November 20, 1954.

BRITISH STANDARD SPECIFICATION.

The following publications of engineering interest have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2, Park-street, London, W.1, at the price quoted at the end of each paragraph.

Symbols on Flow Diagrams of Chemical and Petroleum Plant.—A revision of B.S. No. 974, dealing with symbols for use on the flow diagrams of chemical and petroleum plant, has now been issued. Since the specification was first published in August, 1941, several other specifications for graphical symbols in branches of technology allied to chemical engineering have been issued. Certain discrepancies between corresponding symbols have necessitated the present revision. The symbols have been reduced to their simplest form and made sufficiently pictorial to enable the units of plant represented to be readily recognised. [Price 3*s.* 6*d.*, postage included.]

Methods of Testing Raw Rubber and Unvulcanised Compounded Rubber.—Part 4 of specification B.S. No. 1673, dealing with methods of testing raw rubber and unvulcanised compounded rubber, has now been issued. It refers to the evaluation of vulcanising characteristics and the methods given are intended for use in evaluating rubber on the basis of technically important properties. The specification lays down the test mix and vulcanisation conditions to be used and describes the search test for unvulcanised compounded stock as well as the procedures for conducting mechanical and other tests on samples after vulcanisation. [Price 3*s.* 6*d.*, postage included]

Protective Transformers.—A new specification, B.S. No. 2046, relates to current and voltage transformers for protective purposes. It deals with the performance requirements and special characteristics applicable to the transformers in non-balanced protective equipment and for the operation of earth-fault devices with time-lag characteristics. Many of the requirements relating to such transformers are similar to those for the instrument transformers covered by B.S. No. 81. For this reason, many of the clauses in the latter have been embodied in the new specification. This is divided into three main sections; the first deals with matters which, in general, are common to both protective current and protective voltage transformers. The second and third sections deal more specifically with the requirements relating to current and voltage transformers respectively. [Price 7*s.* 6*d.*, postage included.]

Winchester Bottles.—A revision of B.S. No. 830, covering Winchester bottles, has recently been issued to replace that published in 1939. On account of wartime difficulties of supply the original specification was not widely used and the present revision is consistent with current practice. It relates to plain and fluted 80-oz. and 90-oz. bottles and, in order to facilitate storage and outer packaging, the same maximum diameter has been adopted for both types in each capacity. Alternative types of neck finishes are provided. [Price 2*s.*, postage included.]

Spectrographic Analysis of Low-Alloy Steels.—A new specification, B.S. No. 1121B, covering a recommended method for the spectrographic analysis of low-alloy steels constitutes part of a programme of standard methods for the determination of elements in iron and steel. It is based on the work of the spectrographic analysis sub-commitee of the British Iron and Steel Research Association, a report of which has been published by the Iron and Steel Institute as Special Report No. 47: "Spectrographic Analysis of Low-Alloy Steels." The method provides for the excitation of the samples by means of a condensed spark discharge. A flat sparking surface technique is employed, the emitted spectral radiations being dispersed by a large quartz-prism spectrograph and recorded on a photographic plate. The internal standard method, in which the density of a chosen spectral line of the element being determined is compared with the density of a chosen iron line, is used to make an evaluation from the spectrogram. The method is applicable to the analysis of low-alloy steel having an iron content of 95 ± 1 per cent. [Price 5*s.*, postage included.]

Christmas Lecture of the Institution of Electrical Engineers.—"Electricity Through Gases" has been chosen by Dr. J. H. Mitchell as the subject for the Christmas juvenile lecture of the Institution of Electrical Engineers, to be delivered by him at the Institution, Savoy-place, Victoria-embankment, London, W.C.2, on Thursday, December 31, and repeated on Friday, January 1, 1954, commencing at 3 p.m. in each case. No knowledge of electricity will be assumed and there will be experimental demonstrations. Tickets may be obtained from the Institution at the above address, provided application is made promptly.

UNDERCARRIAGE FOR NAVAL AIRCRAFT.

BRITISH MESSIER, LTD., GLOUCESTER.

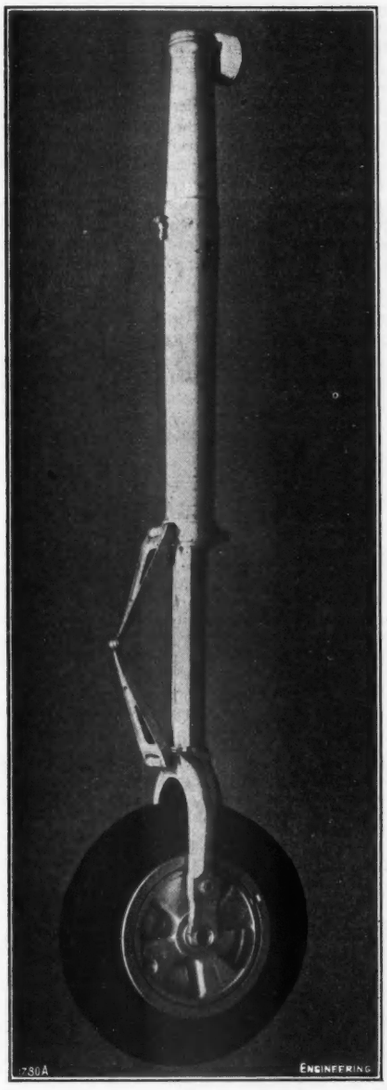
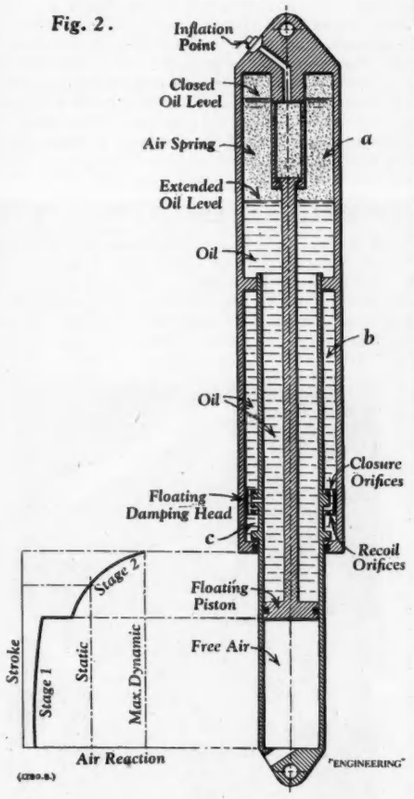


FIG. 1. UNDERCARRIAGE LEG WITH DASHPOT SHOCK ABSORBER.

Fig. 2.



UNDERCARRIAGE FOR NAVAL AIRCRAFT.

OWING to the difficulties inherent in deck landings, undercarriages for carrier-borne aircraft are required to withstand higher landing velocities than are land-based aircraft, and it has become necessary to adopt longer shock-absorber strokes. To eliminate the low rolling frequency of an aircraft parked on the deck which results from the use of a conventional long-stroke shock-absorber unit, a new type of dash-pot shock absorber, with a vertical axial travel of 20 in., has been developed by British Messier, Limited, Cheltenham-road, Gloucester. Fitted with this type of landing gear, an aircraft is inherently stable when parked on a rolling deck, and is also capable of landing at a high descent velocity—16 ft. per second—without severe rebound.

A typical undercarriage leg incorporating the Messier dashpot shock absorber is shown in Fig. 1, and a longitudinal sectional diagram of the shock absorber is reproduced in Fig. 2. The principle of operation is as follows. The greater part of the impact energy is absorbed in the oil in the normal manner, the remaining energy being stored in two air springs in series. One spring is just capable of extending the leg when the ground reaction is completely removed. The other spring has a higher rate and is strong enough, when approximately half closed, to support the static aircraft weight. The two spring rates are derived from a single air spring by changing the rate of oil displacement at some pre-determined stage of the closure stroke.

Referring to Fig. 2, the landing energy is dissipated by oil passing through closure orifices in the floating damping head from *b* to *c*. During the first stage of closure, an air spring in the space *a* is loaded by the rise of fluid level resulting from the fluid displacement of the annular volume of the sliding tube. During the second stage, the rate of oil displacement into the air space is increased by the floating piston "bottoming" on stops in the sliding tube.

On recoil, as the strut extends, oil flows through recoil orifices in the floating head, from *c* to *b*. The comparatively low recoil energy is thus dissipated into the oil. The orifices are designed so that the leg, during recoil, will not extend beyond the point where the spring rate changes so long as the static weight of the aircraft is being sustained. When parked on a rolling deck, compression and extension of the shock absorber are limited by the high-rate spring. It is thus possible to store only a small amount of energy in the shock absorber.

The dash-pot shock absorber is simple to maintain, with a single air-inflation point, and it is light in weight. The manufacturers claim that, when installed on a naval aircraft, the undercarriage weighs less than 5 per cent. of the all-up weight.

CEMENT WORKS.—Two new cement works, one at Cauldon, Staffordshire, and the other at Westbury, Wiltshire, are to be built at a cost of 5,000,000*l.* by Associated Portland Cement Manufacturers, Ltd., the parent company of the Blue Circle group of cement manufacturers and distributors. Each of the works will have an annual output of 175,000 tons. At Cauldon production will be by the "dry process," in contrast to the normal "wet process." It will be the first dry-process works in the United Kingdom.

LAUNCHES AND TRIAL TRIPS.

M.S. "SYLVANIA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the Panamerican Shipping Co., Inc., Panama. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,640 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Loaded speed, 14¼ knots. Delivered, September 24.

M.S. "BJÖRGSUND."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for A/S Hakedal (Managers: Hjalmar Björge), Oslo, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, 18,100 tons on a draught of about 30 ft. 5 in.; oil-tank capacity, about 856,000 cub. ft. Eriksbergs-B. and W. eight-cylinder two-stroke single-acting Diesel engine, developing 9,000 i.h.p. Speed, 15¼ knots fully loaded. Launch, October 14.

S.S. "CLAN STEWART."—Single-screw cargo vessel, to carry twelve passengers, built by the Greenock Dockyard Co., Ltd., Greenock, for the Clan Line Steamers, Ltd., London, E.C.3. Last vessel of a series of four. Main dimensions: 476 ft. between perpendiculars by 66 ft. by 40 ft. 8 in. to upper deck; deadweight capacity, 11,100 on a mean draught of 28 ft.; gross tonnage, 8,450. Reaction steam turbines with double-reduction gears, to develop 9,400 s.h.p. at 108 r.p.m. and a speed of 16¼ knots in service, constructed by Parsons Marine Steam Turbine Co., Ltd., Wallsend-on-Tyne; and two oil-fired steam-generating units constructed by Babcock and Wilcox, Ltd., London, E.C.4. Machinery installed by John G. Kincaid & Co., Ltd., Greenock. Launch, October 22.

M.S. "OCTAVIAN."—Twin-screw oil tanker, built by Swan, Hunter, and Wigham Richardson, Ltd., Wallsend, for Mr. Hilmar Reksten, Bergen. Main dimensions: 625 ft. between perpendiculars by 86 ft. by 46 ft. to upper deck; deadweight capacity, about 31,000 tons on a draught of 34 ft. 6 in.; gross tonnage, 20,500; oil-tank capacity, 1,410,000 cub. ft. Two Wallsend-Doxford five-cylinder two-stroke opposed-piston oil engines, together developing 11,000 b.h.p. at 116 r.p.m., constructed by the Wallsend Slipway and Engineering Co., Ltd., Wallsend-on-Tyne. Service speed, 14¼ knots. Launch, October 26.

M.S. "LONDON PRESTIGE."—Single-screw oil tanker built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for London and Overseas Freighters, Ltd., London, W.1. Main dimensions: 591 ft. 11 in. overall by 80 ft. by 42 ft. 3 in. to upper deck; deadweight capacity, about 24,600 tons on a draught of 32 ft. 3½ in. N.E.M.-Doxford six-cylinder two-stroke single-acting opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, 14 knots. Launch, November 5.

M.S. "BERA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, for the Rederi AB Transocean, Gothenburg, Sweden. Main dimensions: 508 ft. 10 in. overall by 63 ft. 6 in. by 35 ft. 2 in.; deadweight capacity, 13,590 tons on a draught of 27 ft. 8 in. Götaverken seven-cylinder single-acting two-stroke Diesel engine, developing 5,250 b.h.p. at 112 r.p.m. Speed, 14¼ knots, fully loaded. Delivered, November 5.

S.S. "FREDERICK JOHN EVANS."—Single-screw collier, built by S. P. Austin and Son, Ltd., Sunderland, for the North Thames Gas Board, London, W.8 (Managers: Stephenson Clarke, Ltd., London, E.C.3). Main dimensions: 344 ft. overall by 46 ft. by 22 ft. 4 in. to upper deck; deadweight capacity, about 4,600 tons on a mean summer draught of 20 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Service speed, 10¼ knots. Launch, November 6.

M.S. "CAMILLA."—Single-screw oil tanker built and engined by Götaverken Shipyard, Gothenburg, for the Rederi AB Transmark, Gothenburg, Sweden. Main dimensions: 555 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,420 tons on a draught of 30 ft. 2¼ in. Götaverken nine-cylinder two-stroke single-acting Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Speed, 14¼ knots, fully loaded. Delivered, November 12.

M.S. "EDMUND GARDNER."—Single-screw pilot tender, built by Philip and Son, Ltd., Dartmouth, for the Mersey Docks and Harbour Board, Liverpool. Main dimensions: 165 ft. by 31 ft. 6 in. by 14 ft. 9 in.; mean draught, 10 ft. 4 in. The General Electric Co., Ltd., Birmingham, are the main contractors for the propelling machinery, which consists of two 640-b.h.p. six-cylinder Diesel engines (constructed by the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne), each driving 375-kW and 80-kW generators in tandem. These provide power for the single armature propulsion motor, which develops 920 s.h.p. at 300 r.p.m. Service speed, 13¼ knots. Trial trip, November 26.

NOTES ON NEW BOOKS.

Principles of Electronics.

By H. BUCKINGHAM, Ph.D., A.M.I.E.E., and E. M. PRICE, M.Sc. (Tech.). Cleaver-Hume Press Limited, 42a, South Audley-street, London, W.1. [Price 15s.]

THE first five chapters of this book, which is one of the Cleaver-Hume Electrical Series, edited by Professor H. Cotton, are devoted to a discussion of the general theory of electronics as an essential preliminary to the study of the industrial applications of this branch of electrical knowledge. The following six chapters give details of the principal electronic devices and their operation, while the remaining seven are devoted to their application to a number of purposes in industry and elsewhere. The field covered is so wide that it is not surprising that the descriptions are highly condensed, and for that reason it is probable that the student will find the first section most useful. In any event, it will be necessary for him to supplement his reading of this book by a perusal of the numerous papers and articles on electronic applications. The absence of a bibliography will not make this task easier, something more adequate might have been provided in the way of an index.

The J. and P. Switchgear Book.

By R. T. LYTHALL, M.I.E.E., M.Am.I.E.E. Fifth edition. Johnson and Phillips, Limited, Charlton, London, S.E.7. [Price 35s. net.]

A BOOK which has reached a fifth edition either contains much that is permanently useful and attractive to the reader or covers a subject in which great progress has been made. The *J. and P. Switchgear Book* complies with both clauses, since it outlines modern practice in this branch of electrical engineering, suitably to the needs of the non-specialist, and deals adequately with the many developments which have taken place since it was first published in 1938. The present edition contains some 100 additional pages, owing to the inclusion of chapters on automatic voltage regulators and surge protection and of a new appendix on voltage and current phenomena under conditions of short-circuit. All the descriptive chapters have been re-written to bring them into line with current practice, and there are many new illustrations. The ground covered includes both direct-current and alternating-current switchgear. A chapter on the theory of current interruption is followed by some 100 pages dealing with oil-immersed, low oil-content and air-blast circuit-breakers, illustrated with clear photographs and drawings of equipment for operating at voltages up to 400 kV. Each chapter has an up-to-date bibliography. Other subjects covered are high-rupturing capacity fuses, operating mechanisms, control boards, supervising remote control, instrument and protective transformers, protective systems, current limiting reactors, and air-break and oil-immersed flameproof switchgear.

Cours de Mécanique. Tome I: Statique.

By Professor HENRY FAURE. Second edition. Éditions Leemann, 64, Stockerstrasse, Zürich. [Price: paper covers, 32 Swiss francs; bound in cloth, 35 Swiss francs.]

PROFESSOR FAURE'S three-volume *Cours de Mécanique* is based upon lectures given by him at the École Polytechnique Fédérale, Zürich, with the needs of engineers particularly in mind. The first volume, on Statics, originally published in 1946, was reviewed on page 604 of our 165th volume. The remaining two volumes have appeared in the meantime and certain of the omitted topics mentioned in that review, such as the principle of virtual work and the energy stored in bodies under strain, are included in them. No major changes have been found necessary in this second edition of the Statics volume. The main text is divided into three parts. The first, devoted to the statics of rigid solid bodies, includes a chapter on friction and, somewhat incongruously, one on the equilibrium configurations of flexible strings. The second part deals very clearly with the statics of elastic solid bodies, but the third part, limited to a dozen pages on hydrostatics, might well have been extended. Minor alterations have been introduced to improve the presentation and remove possible difficulties. The more important additions consist of the application of the Mohr circle diagram to the graphical determination of the principal stresses when the components of the stress tensor are given in any Cartesian co-ordinate system, and an extension of the discussion on the general stress distribution in the vicinity of a point in an isotropic elastic medium. The sets of examples, not always a feature of French texts, will materially increase the value of the book to students. Most of the diagrams would be easier to read had they been larger.

OVERHEAD CONVEYOR KIT.

A FEATURE of the overhead chain conveyor known as the "P.C.P.," recently introduced by Geo. W. King, Limited, Stevenage, is that it is available in standard parts for assembly by the purchaser to suit his particular requirements. The illustration, in Fig. 1, of an installation in the body-trim department of a motor-car factory, indicates the type of tortuous path to which these standard parts can be adapted.

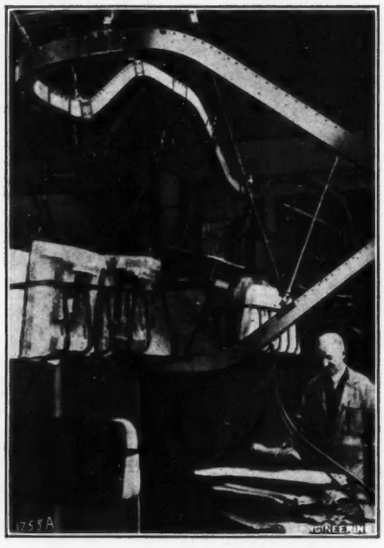
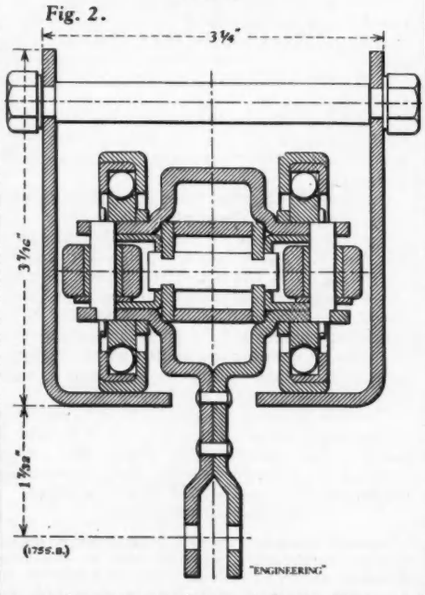


FIG. 1.

Fig. 2.



The track is made up from pairs of pressed-steel sections, supplied in the lengths of 10 ft. and drilled with holes at 2 in. centres, so that no drilling is necessary on site. The pairs of sections are held in their relative position by means of through bolts and distance pieces, as shown in Fig. 2. The track is suspended by the "Den-Tang" system, which employs a roof attachment and a swivelling track attachment, connected by a steel suspension tube cut to the required length. The suspension tube is connected to the two fittings by sliding them over the ends of the tube. Two ½-in. rivets are then inserted in holes provided in the fittings so that they bear at right angles against the suspension tube. A short cover tube, or ring, is then slipped over the rivet heads, forcing them inward to bear against the suspension tube sufficiently to dent it and so firmly grip it. Vertical bends up to 90 deg. and horizontal bends of any angle are available, and the makers claim that the only tools required to assemble the conveyor are a hacksaw, a spanner and a clamp.

The chain and trolley assembly is designed for load-carrying wheels at 8 in. centres. Fig. 2 also shows a cross section through the "Tuwey" wheel used, which has two ball-bearing wheels running directly on the track, and also two self-lubricating hardened-steel rollers mounted on vertical axes to meet side thrust on horizontal bends. Each trolley is rated at a capacity of 100 lb., which may be doubled when two trolleys are linked together.

CONTRACTS.

ENFIELD CABLES LTD., Victoria House, Southampton-row, London, W.C.1, are now making the final shipments to the U.S.S.R. of an order for insulated cables placed in this country in July by the Soviet Union. Deliveries are a month in advance of the scheduled dates specified by the buyers. The order has involved the manufacture of 230 km. (route length) of different types of power cable, 100 km. (route length) of multicore signalling cables, and some 12,580 loop km. of telephone cable.

During the past month contracts have been placed by the British Electricity Authority for plant and equipment for power stations, transforming stations and transmission lines amounting, in the aggregate, to 8,860,590*l*. The principal contracts include: for Brunswick Wharf power station, Poplar, 132-kV 2,500-MVA switchgear, with the BRITISH THOMSON-HOUSTON CO., LTD.; for Portishead "B" power station, near Bristol, structural steelwork for turbine house and annexe, bunker bay and boiler house with SIR WILLIAM ARROL & CO. LTD., also main and auxiliary power cables, control cables, accessories and station earthing system with W. T. GLOVER & CO., LTD.; for Goldington power station, Bedford, superstructures with the MITCHELL CONSTRUCTION CO., also a 30,000-kW turbo-alternator with the BRITISH THOMSON-HOUSTON CO. LTD., and condensing and feed-heating plants for a turbo-alternator set with G. & J. WEIR LTD.; for Hams Hall "C" power station, near Birmingham, 132-kV 3,500-MVA switchgear with A. REYROLLE & CO. LTD.; for Ocker Hill power station, Tipton, Staffordshire, three 180,000-lb. per hour boilers with BABCOCK AND WILCOX LTD.; for Stourport power station, 66-kV switchgear and accessories with the ENGLISH ELECTRIC CO. LTD.; for Connah's Quay power station, near Flint, two 36-MVA generator transformers with C. A. PARSONS & CO. LTD.; for Ince power station, near Ellesmere Port, 11·8-kV and lower-voltage cables and connections with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO., LTD.; for Ferrybridge "B" power station, Yorkshire, two 760,000-lb. per hour boilers with the STIRLING BOILER CO. LTD., coal-handling plant with MITCHELL ENGINEERING LTD., and a 120-MVA generator transformer with C. A. PARSONS & CO. LTD.; for Dudley substation, Worcestershire, 132-kV 2,500-MVA switchgear with the GENERAL ELECTRIC CO. LTD.; for Monk Fryston substation, Yorkshire, 275-kV 7,500-MVA switchgear with the BRITISH THOMSON-HOUSTON CO., LTD., and for Penwortham substation, near Preston, 132-kV overhead lines with BRITISH INSULATED CALLENDER'S CONSTRUCTION CO. LTD.

CHRISTMAS LECTURES OF THE ROYAL INSTITUTION.—Mr. J. A. Ratcliffe, O.B.E., F.R.S., reader in physics at Cambridge University, will deliver this year's course of Christmas lectures, the 124th of the series, at the Royal Institution, 21, Albemarle-street, London, W.1. The lectures, which are, as previously, specially adapted for a "juvenile auditory," will this year be entitled "The Uses of Radio Waves." There will be six lectures in all, to be delivered at the Institution on December 29 and 31, 1953, and on January 2, 5, 7 and 9, 1954, at 3 p.m. Tickets, price 20*s.* for juveniles and 40*s.* for adults, are obtainable from the Institution.